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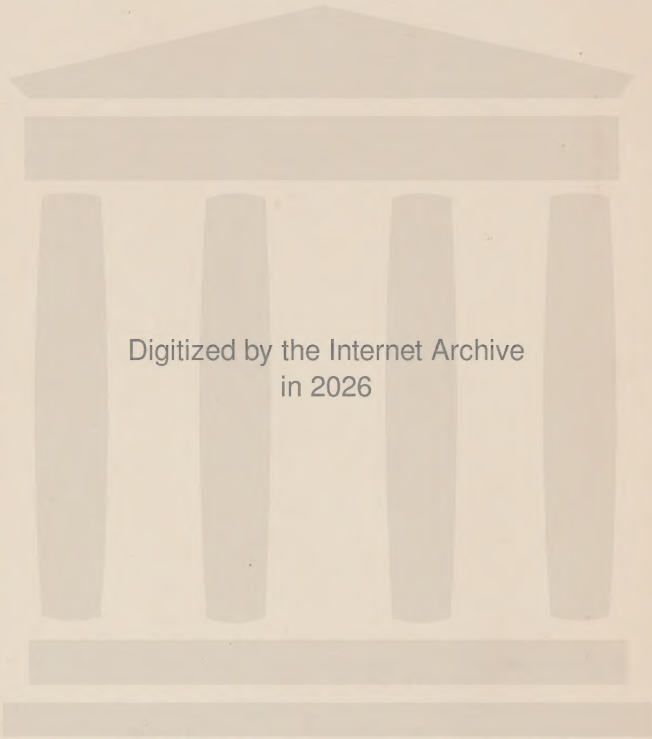

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SCIENCE READERS

FOR

SILENT READING

BOOK V

MAKERS OF PROGRESS

BY

WILLIAM L. NIDA

AND

STELLA H. NIDA

D. C. HEATH AND COMPANY

BOSTON ATLANTA NEW YORK SAN FRANCISCO LONDON CHICAGO DALLAS

SCIENCE READERS

FOR

SILENT READING

Book IV Animal Life

Book V Makers of Progress

Book VI Early Men of Science

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TO THE TEACHER

The time comes early in child life when little people hunger for Truth. "Is this story true?" asks the child again and again of teacher and parent, and he rejoices deeply when answered in the affirmative. We have no doubt been feeding an unbalanced reading diet—one too heavy with fairy tale and fiction and too light in matters of fact and truth.

It ought not be necessary to present arguments in behalf of science in this scientific age. Many years have gone by since Herbert Spencer first showed the great utility of science as educative pabulum. After a long hard fight science won its way into the colleges and then into the high schools, but how to get some scientific truth into the course in the grammar grades has been difficult to solve.

For many years the authors have been at work on this series searching for material not too difficult and still interesting and worth while, and testing it out in the schools. No one familiar with child interests will deny the strong appeal to him of all animal life. Book III, *The Baby Animal Zoo,* and Book IV, *Animal Life,* have proven highly interesting to children of these grades.

For Book V we have taken the great inventors whose problems make such fine educative material. If our chief business is to teach children to think, here surely is splendid subject matter to this end. Moreover, it is biographical, and the science and thinking are cemented to human action and endeavor. The great popularity of general library books on invention should convince us that we were tardy in seizing upon this material for classroom use.

For Book VI, *Early Men of Science,* the material is also biographical and full of stimulating problems. Here we dip pleasantly into astronomy and other branches of science through the lives of the great men who blazed the difficult pathways.

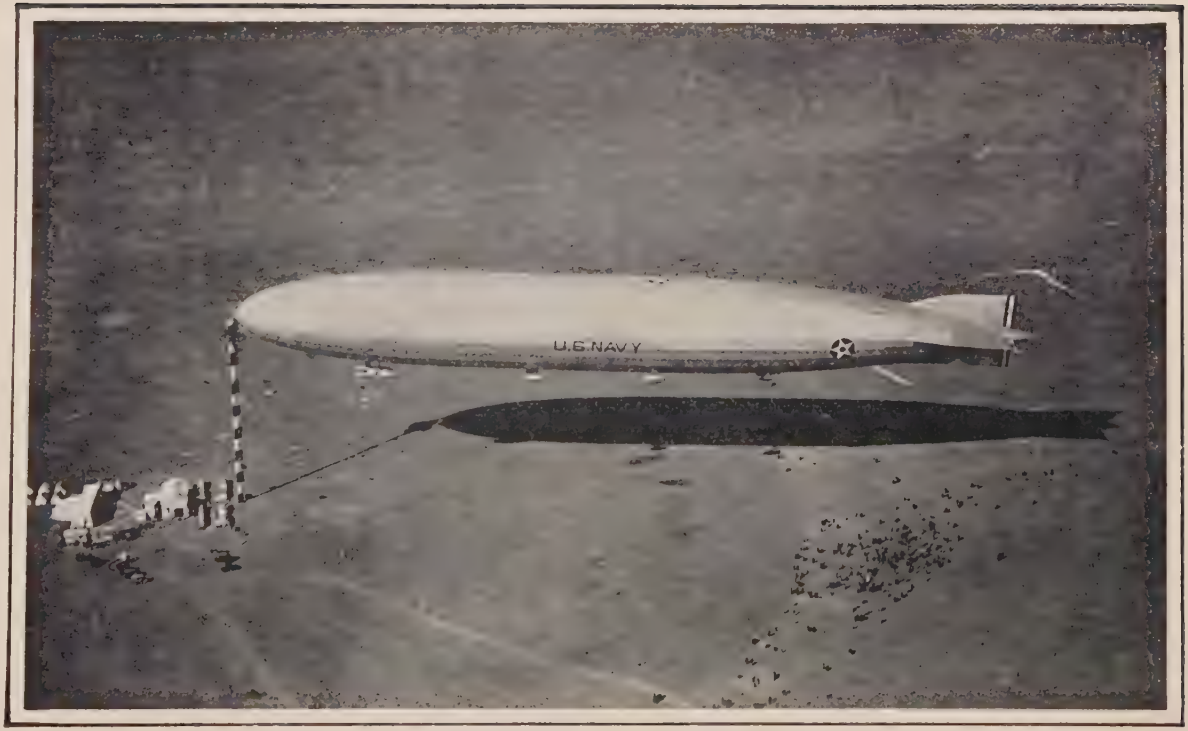
We have no cocksure method to offer. But in these days of stress on silent reading we wish to point out two vital qualities of good silent reading material. It should be interesting and full of challenging problems for the child mind; and there must be pointed questions to check the understanding. In these respects we submit that this series has few equals.

The authors have doubtless overlooked errors and will appreciate corrections, but the subject matter is fresh and interesting and we send it forth with confidence to the school children of America.

THE AUTHORS.

TABLE OF CONTENTS

CHAPTER		PAGE
I	GUTENBERG AND THE PRINTING PRESS	1
II	THE STORY OF THE MAKING OF STEEL	10
III	HENRY BESSEMER	17
IV	JAMES WATT AND THE STEAM ENGINE	26
V	STEPHENSON AND THE LOCOMOTIVE	33
VI	FRANKLIN'S FAMOUS EXPERIMENT	41
VII	ELI WHITNEY AND THE COTTON GIN	50
VIII	ROBERT FULTON AND THE STEAMBOAT	57
IX	JOHN ERICSSON	65
X	McCORMICK AND THE REAPER	74
XI	ELIAS HOWE AND THE SEWING MACHINE	81
XII	THE GAS ENGINE	85
XIII	THE AUTOMOBILE	91
XIV	GOODYEAR AND RUBBER	97
XV	THE WRIGHT BROTHERS AND THE AIRPLANE	106
XVI	THE STORY OF AIRSHIPS	116
XVII	THE SUBMARINE	129
XVIII	THE SUBMARINE IN THE WAR	136
XIX	OTTMAR MERGENTHALER AND THE LINOTYPE	147
XX	CHRISTOPHER SHOLES AND THE TYPEWRITER	152
XXI	THE STORY OF THE TELEGRAPH	160
XXII	ALEXANDER GRAHAM BELL	170
XXIII	THOMAS ALVA EDISON	180
XXIV	EDISON'S INVENTIONS	185
XXV	MARCONI AND THE WIRELESS	192
XXVI	THE RADIO TELEPHONE	201



The End of the First Transcontinental Flight

CHAPTER I

GUTENBERG AND THE PRINTING PRESS

JOHN GUTENBERG was born in Mainz, Germany, about the year 1400. When he was married, he went with his wife, Anna, to live in Strasburg, some sixty miles from his native city.

Gutenberg was a polisher of precious stones and came to possess great skill in cutting gems. He was called a lapidary, and his art was held in great esteem. He was as much honored as a sculptor or painter. Gutenberg came from an excellent family. He had a good education and a thinking mind, and the whole world was to benefit because of his use of it.

One evening after supper as he and his wife sat cozily in their room behind the shop, he picked up a playing card. He looked at it so intently and examined it so carefully that his wife noticed it and laughingly said: "Do tell me what marvel you find in that card. One would think it the face of a saint, you look at it so closely."

"I was just thinking how this picture is made," said Gutenberg.

"I suppose it was drawn in outline and then painted, as other pictures are," said his wife.

"No, there is a better way," said Gutenberg. "These lines were first marked out on a wooden block, and the wood was cut away on each side of them so

that they were left raised. Ink was then spread over the raised figure and it was printed on the cardboard. This is a much shorter way, Anna, than by drawing and painting each card separately; because when the block is once made, it can be used to print any number of cards."

The picture on the card was a colored woodcut. Gutenberg became interested in the idea of making pictures and books with woodcuts. In those days books were written in longhand by scribes and monks. Since each one cost such a vast amount of care and labor, we should expect all books to be very expensive, and they were. Only rich people could afford them. So it is no wonder that the millions of poor people of that time were very ignorant and ready to believe anything that was told them. Very few of them could read.

Gutenberg took a small piece of wood from the work table in his shop and marked certain lines upon it. He cut away the wood so that it left the letters of his wife's name. Then he inked the raised letters and pressed the wood upon a sheet of paper.

"Wonderful!" said his wife, when she saw her name. "The letters have all the appearance of writing."

Encouraged by this success, Gutenberg went farther with this process of engraving. He had some trouble in finding the right kind of wood. Some was too hard and some too soft, and other kinds split too easily. Finally, he chose the wood of the apple tree, which suited all his needs.

Then Gutenberg drew the picture of a saint on a block and wrote an inscription beneath it. He cut the wood away and inked the block and pressed it on paper. There was the picture and the inscription.

"It is not perfect," he said to his wife; "but it is better and clearer than the picture on the playing card. I must have thicker ink. This is too thin; it blots and blurs in printing." He solved the problem of ink by mixing oil and lamp black for a black ink, and amber and other mixtures for colors.

Gutenberg printed several copies of the saint and placed them in his shop where people came to look at his jewels. His customers were more interested in his pictures than in his gems. Every one who came admired his pictures, and many bought them and went away forgetting all about the gems. But it was on the gems that he made real profit.

"It is hurting my business. Perhaps I had better stop it," said Gutenberg. But his wife urged him to keep on with the wood-cut printing, thinking that it might develop into a better business than the gems.

Gutenberg kept his secret about the new discovery of picture making. One day Anna urged him to show his pictures to the Abbot. The Abbot was much interested and purchased all he had made to hang upon the walls of the monastery. One day the Abbot gave Gutenberg a beautiful book written on parchment with a quill pen. It was called the "History of Saint John." There were over sixty pages. Some patient scribe had spent months writing this book.

"I shall engrave these pages as I did the picture," said Gutenberg.

Anna thought it a wonderful idea. "You can sell books as well as the monks; and after you have made the engraving, it will take you a much shorter time to print them," said she.

So John set to work. Night after night when his day's work was done, he kept busy engraving the pages of the book. He told no one but his wife of his plans. One evening two of his assistants in the shop happened in and discovered him at work with the wooden blocks all about him. They insisted on knowing his secret, and then offered to help him both with their time and money.

Soon there were four men at work cutting blocks, each one to print a page of the book. When they had finished, Anna said she could help in making the impressions. She used only one side of the paper and pasted the blank sides together.

The history was soon ready to sell. Gutenberg engaged a young student by the name of Peter Schœffer to help sell the books. The first week he sold only two copies. The poor people of the city could not read, and the rich people were hard to reach. The priests at first said they could copy their own books.

Gutenberg and his friends next cut fifty pages of a grammar that was used by the students at the cathedral, and these sold readily, for they were cheaper than those written in longhand.

Gutenberg made woodcuts for two other books used

by the priests. They were amazed at the short time it took him to do them and said: "You must do it by magic. Every few weeks you bring us twelve books. You can write them in half the time it takes our scribes to make them."

The Abbot soon guessed Gutenberg's secret. He said: "You make these books the same way you made the pictures. I want you to make a Bible for the poor." Gutenberg said he would like to do it if he were sure he would be paid for his work.

John talked it over with his wife. "There are seven hundred pages of the Bible, and if I work all my spare time, I can engrave only two pages a month. It would take me thirty years to print the Bible."

"You would be old before it was done unless you got a great many people to help you," sighed Anna.

However, Gutenberg and his friends started to engrave the gospel of Matthew. When the first page block was nearly done, he let his knife slip and split the block. All his work was spoiled.

As he sat studying over his mishap, he got the notion of cutting the block into small pieces and using the letters separately. This was a great idea. Soon he had a pile of single letters. Then he added the other letters of the alphabet all on separate pieces of wood. He called them *stücke*, or type. He tied several of them closely together, and made the words "Good man." In order to do this, he was reminded that he would need more than one letter of a kind, so he made several more. He put the letters in separate boxes,

and in time invented a press to hold his type together when it was set for printing.

Next Gutenberg started to make a dictionary. Then one of his partners died and the heirs claimed part of the invention. There were no patents in those days to protect any one's discovery. The printing press was in the house of the man who had died, and part of it was stolen.

"They will steal my whole secret," said Gutenberg. So he took a hammer and broke the type into bits.

Then he went back to his gem cutting, but his heart was still in the printing. His wife urged him to try again. He went back to his birthplace at Mainz, where no one knew of his plans. There he met a wealthy man named Fust, who became interested in his idea. Fust promised to give him three thousand florins for a partnership. It was agreed. They took a large house and worked secretly, Peter Schœffer with them.

They found that the ink softened the wooden letters, so that after being used a while they failed to make clear impressions. The printers then tried iron, but that cut the paper. Lead was also tried, but it was too soft.

"Let us find something hard and melt it with the lead," said Gutenberg. So Schœffer made an alloy, or mixture of lead and antimony, which worked well. Later Schœffer became a partner, and suggested many improvements in the type and printing. He found an easier way to cut the type than to make it all by hand. All this time they worked secretly.

In 1450 they began to print the famous Nazarene Bible. It was finished in five years, but did not pay for the time put on it. Fust was disappointed at Gutenberg's business methods. He flattered Schœffer, and told him he had really discovered more things about the printing than Gutenberg.

"Let us get rid of Gutenberg," said Fust. "You invented the ink and the forms for casting the new type and the alloy. Gutenberg only spends money faster than we can make it. He will never repay me what he owes me."

Schœffer knew he was doing Gutenberg a wrong, but he was in love with Fust's daughter and did not want to anger Fust.

Fust roughly demanded his loan of Gutenberg, who could not pay it.

"Would you ruin me?" asked Gutenberg. "You know I have no money."

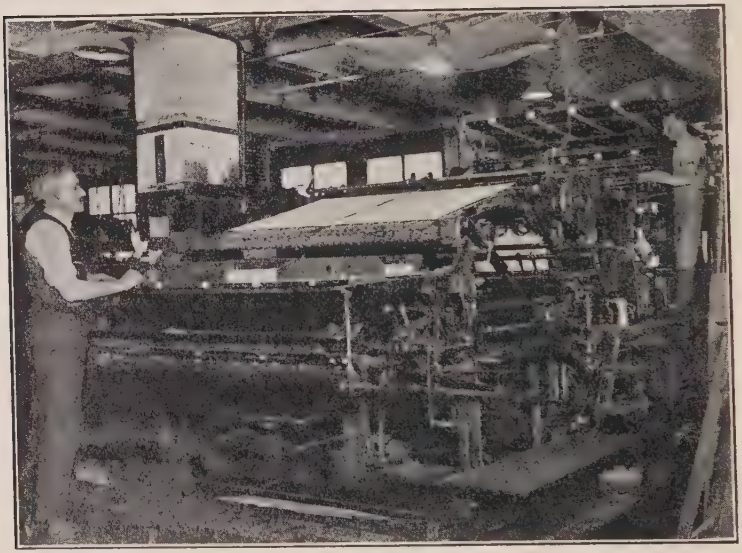
"You must pay me in thirty days," said Fust.

Gutenberg again begged Fust not to ruin him, but Fust started a lawsuit to recover his money with interest. He soon had possession of all the presses, the type, and the extra copies of the Bible that had been printed.

Gutenberg was crushed. "They have stolen my invention, and I have nothing left!" he groaned to his faithful wife, as they left the house.

Schœffer married Fust's daughter and he and his father went on with the secret printing. To advertise his printing, Fust went to France where he sold a copy of the Bible to the King for seven hundred and

fifty crowns. It was such a mystery that some one started a report that Fust dealt in the black art. He was brought into court, and had to tell the secret of the printing press. When he had convinced the court of his invention, he received much praise and honor, and came back to Mainz with all the success that belonged to Gutenberg.



Kadel & Herbert

Modern Printing Press

In time Fust realized how greatly he had wronged Gutenberg, and begged his forgiveness. He urged Gutenberg to take his old place in the firm, but John would not hear of it. For eight years he carried on his own printing shop with success. Then his good wife, Anna, died and he lost heart for his work. His

brother urged him to travel. By this time he was recognized as the real inventor of printing and received the honor due him. We are glad to know that he was granted a pension, and spent his last days in peace and comfort.

Presses were set up in every city in Germany, and many places in France and Italy. Caxton, an English merchant, started the first English press at Westminster, and books soon began to be printed in great numbers.

The type of the printing press is now made by machinery, inked by machinery, and set up and distributed by machinery, but it all began with Gutenberg's card.

Stereotyping, electrotyping, and linotype machines make printing a quick and cheap process. When we stop to think what the art of printing has meant to education, we place Gutenberg among the first inventors of the world.

Questions and Problems

1 What were books like before the days of printing and how were they made?
2 What was papyrus? Parchment?
3 From what products is paper made to-day?
4 How did Gutenberg make ink? Find out if you can how printing ink is now made.
5 What is an engraving?
6 What can you find out about woodcuts and where now used?
7 Should Anna Gutenberg have any credit for the invention of printing?
8 What was meant by the black art?
9 In what language was the first printing done?
10 What invention could you name that has done more for man than printing?

CHAPTER II

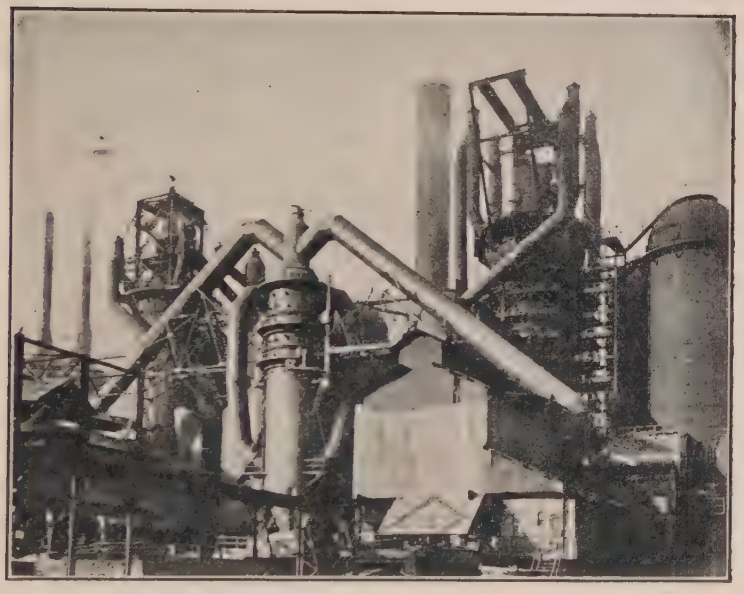
THE STORY OF THE MAKING OF STEEL

THE most important aid to man in all his endeavors to get on in the world has been "iron." Because it is so useful, iron is the most precious metal that we have. Without it we would have neither stoves, kettles nor tools, engines, railroads, nor steel skyscrapers. Without iron we would still be living as did the Indians before the days of Columbus, using weapons of wood or stone and vessels of clay.

While a pound of iron is not worth one of gold, yet when the iron is made into watch springs, it is worth thousands of dollars—more even than an equal weight of gold.

Not many of us have ever seen pure iron, which is soft and white like silver. As soon as iron is exposed to the air, it takes on a coat of rust and becomes black, then red. For this reason the only pure iron in the world is what man has made. Nature gives us less pure iron than gold or diamonds.

Occasionally there falls upon the earth out of a clear sky a great chunk of pure iron weighing many tons, called a meteorite. We do not know what planet or sun meteorites come from. But we do know that their home planet has no air or oxygen, or it could not have rustless iron. In spite of its great strength iron is a timid metal, afraid to be alone. It likes almost every other element better than it likes itself. It has a special liking for oxygen, and since this is



A Steel Mill

abundant both in air and in water, iron is not long in finding its mate. Together iron and oxygen form iron rust.

England, Germany, the United States, and in fact all nations, are madly competing to see which can dig the most iron rust out of the ground to make railroads, bridges, machinery, and battleships.

We do not know when early man first began to use iron. Since iron is not found pure in nature as are some other metals, he did not discover its use for many years. He found tin, copper, and gold in nuggets as big as his fist, which were pure and easy to work, for they are soft. That is the reason early

man first learned to use such metals. Then by mixing tin and copper, another easy step, he invented bronze, which made better tools and weapons than either tin or copper, because it is harder and holds an edge better.

Iron is usually found mixed with clay, rock, or other substances, and in this form is called iron ore. All countries have more or less of it. After a long time man learned to separate the iron from the ore. To do this the ore must be put under great heat, so great that he had a hard time learning how to produce it. But when the iron ore is made hot enough, the pure iron melts and runs out. It is then in form to be made into useful things.

The first iron furnace in which ore was melted was probably no more than a pile of wood with a layer of ore on top covered over with clay to keep in the heat. At the top were one or more holes for smoke to escape as the wood burned. At the bottom were other holes in the clay covering to admit air to the fire. In such a simple furnace a few pounds of iron were melted with several days' hard work. In this toilsome way early man obtained a little iron for axes, knives, and spearheads, which were harder and better than those of bronze.

Who first discovered how to smelt iron ore or how long ago it happened we shall probably never know. It happened many centuries ago. Iron has been found in the pyramids of Egypt, built four thousand years before Christ. Hannibal's soldiers were armed with Spanish swords in 216 B.C. From that time on iron

and steel have been the world's symbol of power both in peace time and in war.

In the battle of Verdun, when France said of the Germans, "They shall not pass," the French guns fired 60,000,000 shells which contained 1,800,000 tons of steel. In the first seventy-eight minutes of Germany's last great drive in 1918, her soldiers fired 650,000 shells.

Kadel & Herbert

LOADING IRON ORE

We are able to trace the steps in the growth of iron and steel production, which has become one of the greatest industries of to-day. After the primitive furnace described above, the next step was that of using charred wood, or charcoal, instead of wood for fuel, because it makes a hotter fire. Then a goat-skin bellows was used to fan the fire by forcing in

more air to increase the heat. How fast a fire burns depends upon how fast it can get air or oxygen.

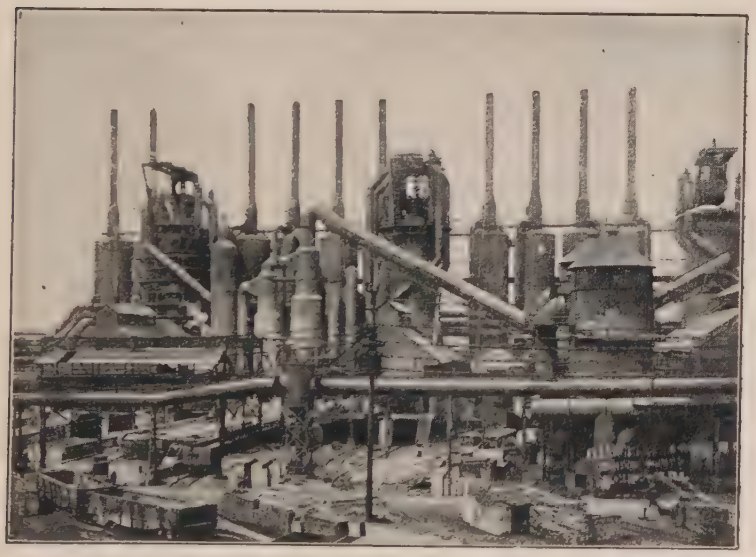
In the course of time, the furnace was built with stronger walls so that it could be used over and over again. It was still a small affair, no more than four or five feet high, and made of clay. An opening was left in front through which the charcoal and ore were put in, layer upon layer. The opening was then closed during the burning, and afterward torn down to take the melted iron out. Such a furnace could make only fifteen or twenty pounds of iron a day.

For more than two thousand years after this method was known and practiced, there was little progress made in producing iron. The furnaces were gradually improved a little until the ore and charcoal were put in at the top and the melted iron drawn off at the bottom. Such a furnace could be kept going for months or even years without being allowed to stop or cool off.

About the time of Columbus, furnaces were built larger, perhaps as high as twenty or more feet, and more powerful bellows had come into use, worked by horse power or water. This was still several hundred years before the modern steam engine came, with a wonderful blower which did away with bellows. The blower delivers a blast of air strong enough to throw a man off his feet, so we speak of the furnace as a blast furnace.

It required so much wood to make the charcoal for smelting iron that the timber was fast disappearing and the people of Europe were alarmed. They tried

to use soft coal, but it was not successful. Then about 1700, some clever man thought of trying to char the coal as they did the wood, and the result was coke, which answered very well for smelting. It was not long till coke was in general use in Europe, but in the United States charcoal continued to be used till after the Civil War.



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A Steel Plant in Illinois

In 1828, another important discovery was made. Cold air had always been used to fan the fire, but an Englishman, named Neilson, found that if the air was heated very hot before it was forced into the furnace, it reduced by one half the coke needed for smelting. This was a great discovery, and made iron much

cheaper. We have, then, the forced blast, the hot blast, and the use of coke—three great steps in the smelting of iron to-day.

The modern blast furnace is built a hundred feet high and will turn out a hundred tons of iron a day—more than would five thousand of the furnaces of ancient times. But while plenty of iron, called pig iron, can be made by the blast furnace, it is not pure enough to be hammered at once into tools and implements, as the ancient iron makers were able to do with their iron. Pig iron can be cast into stove lids and many useful things, but not into high-grade, steel tools. It must be purified to make steel, which was for many years a very costly process. A ton of pig iron could be had for thirty dollars, but a ton of steel cost more nearly three hundred dollars.

Such great inventions as the steam engine, the locomotive, the steamboat, and edged tools called for great quantities of high-grade steel. Who could invent a process for making steel out of pig iron in great quantities, and so reduce the cost that all people who wanted steel products might have them? In time the man appeared—an Englishman, named Henry Bessemer.

Questions and Problems

1 Compare the use of iron with printing in its usefulness.
2 What is iron rust?
3 What are the chief iron-producing nations?
4 How is bronze made and how does it differ from copper or tin?
5 Why was it difficult for early man to master iron making?
6 Describe the early furnaces. What is charcoal? Coke?
7 Why does a fire need air?
8 How did bellows help the iron maker?
9 Give three great steps forward in the smelting of iron.

CHAPTER III

HENRY BESSEMER

AS a boy, Henry Bessemer lived in the woods and fields and among country folk. He went to grammar school, but instead of having a high school education, he spent three years doing the things he liked. The neighbors said he was fooling his time away. He was fond of working on a lathe which his father gave him. With it he made models of machines, one of which was a brick machine. With this he molded little bricks of white clay. He also molded wheels and pulleys.

Henry's father owned a big type foundry, in which the lad spent many a day molding type and mixing different kinds of type metal. He was fond of machinery and of seeing it in motion. "If ever I was absent from meals," he later said, "I could probably have been found at the flour mill gazing with pleasure at the broad sheet of water falling into the buckets of the great water wheel." During all these years he kept his eyes open and did the things that seemed to him worth doing.

By the time young Bessemer was eighteen, he was six feet tall and full of ambition. He had learned to make dies for bookbinders. One day he learned that the government was being defrauded of several hundred thousand dollars a year because people took

stamps from old and useless deeds and used them on new deeds. Bessemer thought he could invent a stamp that would prevent this fraud. So bending all his efforts to the task, he made a die out of steel, and with it punched four hundred little holes in the paper which gave a stamp that could not be removed. As soon as he had finished the die, Bessemer hastened to the president of the Stamp Office, feeling certain that he had made his fortune. The die gave great satisfaction, and to his joy the men of the government decided to adopt it, and it is in use even to this day. It was so simple that thereafter there was no need of a superintendent of stamps, whose salary had been four thousand dollars a year.

"Surely," thought Bessemer, "I shall be well repaid for my invention." At first he was given a promise of a reward, but the officials at the Stamp Office finally told him that he had offered the die to the government of his own free will and that there was no money for him.

He says, "I went my way from the Stamp Office too proud to ask as a favor that which was my just right."

Bessemer had hoped for a reward that would enable him to marry the girl he loved, and this failure was a hard blow. Yet he would not be utterly discouraged. "I have made one good invention and I can make others," he declared to himself.

Henry's sister asked him one day to letter her name on the cover of a flower book. The book was so lovely that Henry wanted something better than

Kadel & Herbert

HENRY BESSEMER

common ink. He decided to do the lettering in a paint made of bronze powder that would look like gold. When he went to a store for the bronze powder, he was amazed to learn that a small ounce bottle cost a dollar and a half.

On his way home Bessemer could not help asking himself over and over again what was in the powder that it should cost such a price. He did not think there was gold in it, and surely brass should not cost so much.

Bessemer was soon at home where a little acid convinced him there was no gold whatever in the powder. It was only powdered brass, and it provoked him to think he had paid for the powder at the rate of twenty-four dollars a pound when brass could be had for twenty-two cents a pound.

"This powder must surely be made by some old-fashioned hand process," he said to himself. "If I can invent a machine to grind brass rapidly and cheaply, I shall make my fortune."

So Bessemer set to work making a machine that would reduce a block of brass to fine powder. The first machine he built did the work; but when the powder was mixed into paint, it was dull, lacking the bright color that was wanted, and he was much disappointed. "This was not the first castle I had built only to see it topple over," he said later.

For some time Bessemer turned his mind to other things. Still the idea of a machine that would make brass worth as much as gold haunted him. He studied closely under a glass the powder he had bought and

that which he had made, and soon saw why his was worthless. Then he tried again, making three machines to do the three parts of the process. Again he was ready for a test. He felt that on the result of this trial hung the whole of his future, and he watched with a beating heart while the machines ground out the powder. It was a success, and his fortune was made.

He kept his machines a secret, and with some faithful workers made enormous profits. Powder that cost him one dollar he could sell for thirty dollars, and he soon made enough money to take care of himself and his family for life. Thus, at the early age of thirty, Bessemer was free to work at other inventions in which he was interested, whether they proved profitable or not.

For the next ten or more years Bessemer was interested in many different inventions, and took out no less than thirty patents. In the year 1854, he was working on a new kind of cannon ball, when he learned that Emperor Napoleon III was searching for better steel for the making of cannon. At that time the good steel was made largely by hand labor, and cost more than three hundred dollars a ton.

A furnace was built with which Bessemer began to experiment. The idea occurred to him that the impurities could be burned out of pig iron by driving a blast of air through the molten iron when under great heat which would change the iron to steel.

Bessemer therefore built what he called a converter, into which led a pipe to carry a forced draft of air.

When all was ready, the converter was filled with molten pig iron and the draft turned on. In a few minutes clouds of sparks and roaring flames burst from the opening at the top. Small explosions began to occur inside the white-hot metal until it was like a young volcano in eruption. Bessemer was much alarmed, and for a few minutes had fears for his life. But after a short time the explosions ceased and the flames died down.

When the molten metal was drawn off, he found the impurities had been burned out and it was steel of good quality. Thus he had made one of the greatest inventions of all time. This process changed iron into steel in thirty minutes, and reduced the cost of making good steel from more than three hundred dollars to three or four dollars a ton.

Shortly afterward, Bessemer read a paper before the iron makers of England, telling how iron could be made into steel without fuel. The iron makers laughed him to scorn. "We will be burning ice next," laughed one of the hearers. But after a while the iron makers went to Bessemer's shop to see the new process, and he sold them the right to use it for thirty-five thousand dollars.

But when these men tried to make steel by this process, they failed, and denounced Bessemer as a fraud. One newspaper said that his invention was only the dream of a wild enthusiast.

Bessemer was stunned by the taunts of the people. He could not understand what it meant until he went to the different furnaces and saw with his own eyes

that it was a failure. Why these furnaces had failed when he had succeeded, he could not understand; but he refused to think of defeat.

Giving his wife fifty thousand dollars to make sure the family should not suffer want, Bessemer resolved to spend every cent of his remaining sixty thousand to prove his invention.

The trouble was that most of the pig iron produced

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BESSEMER CONVERTER

in England at that time contained phosphorus, and, try as he would, Bessemer could not make good steel out of pig iron with phosphorus in it. At first he did not know that the pig iron with which he had succeeded came from Sweden, and had no phosphorus.

When he learned that his first iron had come from Sweden, he immediately ordered more from that country. When it came, he immediately set to work melting it and testing it out for steel. It came out excellent steel, and he rejoiced.

Then Bessemer hired a chemist to try out the English and the Swedish pig iron side by side to find out the difference, and it was then he discovered that the latter had no phosphorus.

When Bessemer forced the air blast through the molten pig iron, the oxygen of the air greedily devoured the carbon and other impure elements all except one, and that was phosphorus. At last he found pig iron in England without phosphorus, and proved his great invention a success. He built a steel mill, and became many times a millionaire. Others who wished to use the Bessemer process paid him a royalty on every ton they made.

When Bessemer tried to get a patent on his discovery in the United States, it was found that William Kelly, an iron maker in Kentucky, had also discovered how to turn molten cast iron into steel by forcing an air blast through it. So our patent office gave William Kelly the credit of being the first inventor of this process and granted him the American patent. But because Bessemer had first brought this process to the attention of the world, it still bears his name.

Bessemer experimented until he found that the finest steel needed a little carbon and manganese. So after first burning these all out of the hot metal, he put back

just the right amount, and the result was high-grade steel. The Bessemer process was both quick and cheap.

Other improvements have since been made in steel making. One is called the open hearth, which is a slower method, but the maker can test his steel many times while he is making it, and can add to the molten mass just the elements to give it strength or hardness or whatever quality he desires.

Questions and Problems

1 How did Bessemer make a stamp that could not be removed?
2 How did Bessemer behave in defeat?
3 How did Bessemer make bronze paint?
4 How did Bessemer plan to take the impurities out of pig iron?
5 How did his converter work?
6 Why was this a great discovery?
7 How did phosphorus trouble the inventor?
8 What elements does high grade steel require?
9 Why is the open hearth method used to-day?

CHAPTER IV

JAMES WATT AND THE STEAM ENGINE

MANY hundred years ago before there was much machinery, the people of England and Scotland could scarcely get enough coal from their mines to supply their needs. They had used the coal from small mines near the surface. Now they had to go deeper into the earth for their fuel. This meant a hard task, for men and women raised the coal in baskets or horses drew it out by a windlass. A machine was badly needed to raise the coal quickly and cheaply. Who could build the machine?

A Frenchman named Papin had built a crude little steam engine. It consisted simply of a cylinder and a piston fitted into it. There was no boiler. The water was placed in the cylinder beneath the piston, a fire was placed under the cylinder, and, as the water boiled, the steam raised the piston. Then the fire was removed and, as the cylinder cooled, the steam condensed and the piston was forced down by air pressure. It required several minutes for this awkward engine to make one stroke, yet it was the beginning of the use of steam to do man's work.

Thomas Newcomen, a blacksmith, improved Papin's idea, making an engine that would pump water from a mine or lift coal. His first engine was able to lift fifty gallons of water fifty yards at each stroke, and could make twelve strokes a minute.

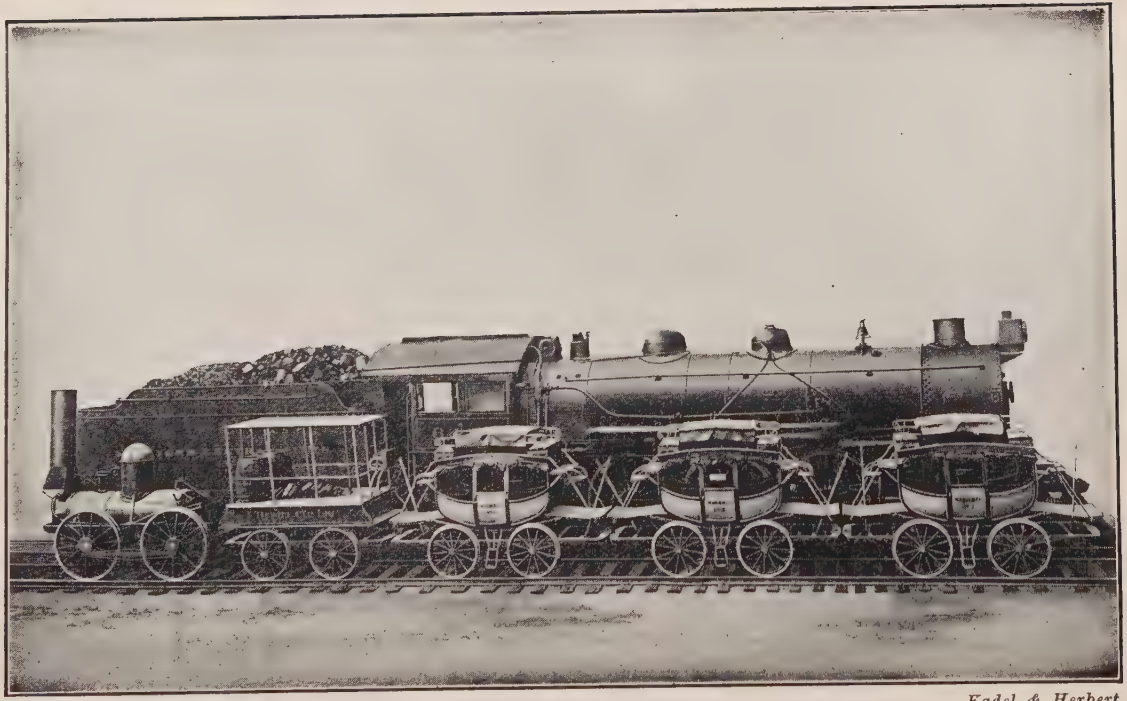
At first Newcomen condensed his steam by throwing cold water on the outside of the cylinder, but one day he discovered that the engine was suddenly running much faster. Upon examination he found that a hole had been worn in the cylinder, and that the water with which he had covered the top of the piston to make it air-tight was entering through this hole. The water was condensing the steam much more quickly. When he made his next engine, he used the jet of water to save time.

Another improvement in the engine was made by a boy named Humphrey Potter, who was employed to turn the cocks that let the water and steam into the cylinder. Young Potter got tired of doing this work by hand, hour after hour, as any boy would, and so he tied strings to the cocks so that the engine would turn them itself. Thus the lad invented what came to be known as the valve gear.

Newcomen's engine was a great help in the coal mines of England and Scotland, but it used so much coal itself that it was very expensive to run. The largest engine consumed many thousand tons of coal a year. Then it happened in 1764 that one of the Newcomen engines needed to be repaired, and it was given to James Watt for this purpose.

There are many interesting stories told about the boyhood of James Watt, but we are not certain that they are all true. He was a quiet boy, not very rugged. He was fond of drawing, but rarely had anything to say about his studies.

The story is told that James was once reproved by



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THE FIRST RAILROAD TRAIN AND THE LOCOMOTIVE OF TO-DAY

his aunt in these words: "James Watt, I never saw such an idle boy; take a book or employ yourself usefully; for the last hour you haven't spoken a word. You have been only taking off the lid of that kettle and putting it on again and holding a cup over the steam. Aren't you ashamed of spending your time in this way?" But James was watching the steam from the teakettle and learning its power. It was this knowledge that helped him later in inventing the steam engine.

When Watt grew up, he became an instrument maker and opened a shop in Glasgow. When the Newcomen engine was given him to repair, he made a careful study of it. Watt saw that when cold water was let into the cylinder to condense the steam, there was a great loss of heat, which cut down the power and increased the expense of running the engine.

Watt realized that the cylinder should not be cooled at all but kept as hot as the steam that went into it. How could this be done?

"I had gone on a walk," he tells us, "on a fine Sabbath afternoon early in 1765. I had entered the green by the gate at the foot of Charlotte Street and had passed the old washing house, when the idea came into my mind that as steam was an elastic body, it would rush into a vacuum; and if a pipe were made between the cylinder and an exhausted vessel, the steam would rush into it and might be there condensed without cooling the cylinder. Then by sending a jet of water into the vessel, the steam would be condensed and the water and air could be pumped out. I had not

walked farther than the golf house when the whole thing was arranged in my mind."

This was the discovery that gave us the modern steam engine, which works for man in a thousand ways. Watt's engine could use the tremendous force of steam under higher and higher pressure. By leading the steam out of the cylinder to a separate vessel, he kept the cylinder hot. He closed the cylinder top and prevented the loss of steam. These improvements made our steam engine. Watt made a crude model of his new engine, and proved that he was on the track of an invention that would utterly change the work of men. But he saw that it would take time and money to make and prove his engine.

He undertook the venture and was soon plunged into debt, but luckily found a man with money who became his partner. Then he had a long fight to obtain a patent so other people could not use his invention without paying him for the right.

At last in 1774, Watt shipped a trial engine to Birmingham, where he went himself to see it set up. It was a great success, and Watt began to travel about the country setting up his engines.

The mines of Cornwall had been abandoned for lack of a better engine. A Watt engine was shipped here, and miners, engineers, and owners gathered to see the new invention. It stood the test wonderfully, making eleven eight-foot strokes per minute, which broke the record. After that other mines of England and Scotland threw out the Newcomen engine and put in the Watt invention, and Watt became well to do.

The inventor spent his time in improving his engine. He invented the condenser, the crank and fly-wheel, and the double-acting engine. Watt also first made the fly-ball governor, which regulated the speed of his engines. His improvements were such that his engine could be made to serve almost any purpose, and might be placed in almost any position.

There was just one more step to take, and Watt

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ELECTRICITY *vs.* STEAM. THE ELECTRIC LOCOMOTIVE WINS

was equal to it. He produced a compound engine, or two engines working together on the same steam. This engine is still in use to-day. Other improvements such as piston rings have been made, but they are only details.

The steam engine had come to take its place in the great forward march of man's progress. What men and women had done before by hand, the engine was to do henceforth in every kind of work requiring power. Thus had the dreams of James Watt over the teakettle been of great service to men and women everywhere.

Questions and Problems

1 What is a windlass and how is it used with horses?
2 What is meant by a cylinder with a piston fitted into it? Make a drawing on the board.
3 Show how Papin's engine worked. How was the cylinder forced down?
4 How did Newcomen condense the steam?
5 How did the Potter lad improve the engine?
6 What was the great weakness of Newcomen's engine that Watt discovered and how did he improve it?
7 What was the condenser? The flywheel? The governor?
8 What is a vacuum?

CHAPTER V

STEPHENSON AND THE LOCOMOTIVE

TO lift the coal from the deep mines of England, James Watt invented the steam engine. It was fixed to one spot and was therefore a stationary engine. No one had yet thought of making an engine which would move itself on a level place and pull a load at the same time. But it was not long after Watt's great invention had been adopted that men wanted a machine to draw cars of coal to market. They placed stationary engines short distances apart along the road. Each one pulled the loaded cars up to it with a long rope. Then they were hitched in like manner to another engine farther on.

In 1802, Richard Trevethick, who was working in a tin mine, invented a steam carriage. The machine looked like an ordinary stagecoach on four wheels. It had an engine of one cylinder placed in the rear of the hind axle together with the boiler and the furnace box. It was a crude affair, as you might guess, but fairly successful, and created a great sensation in the neighborhood where it was built. On the road it caused amazement and fear, and people called it the "dragon."

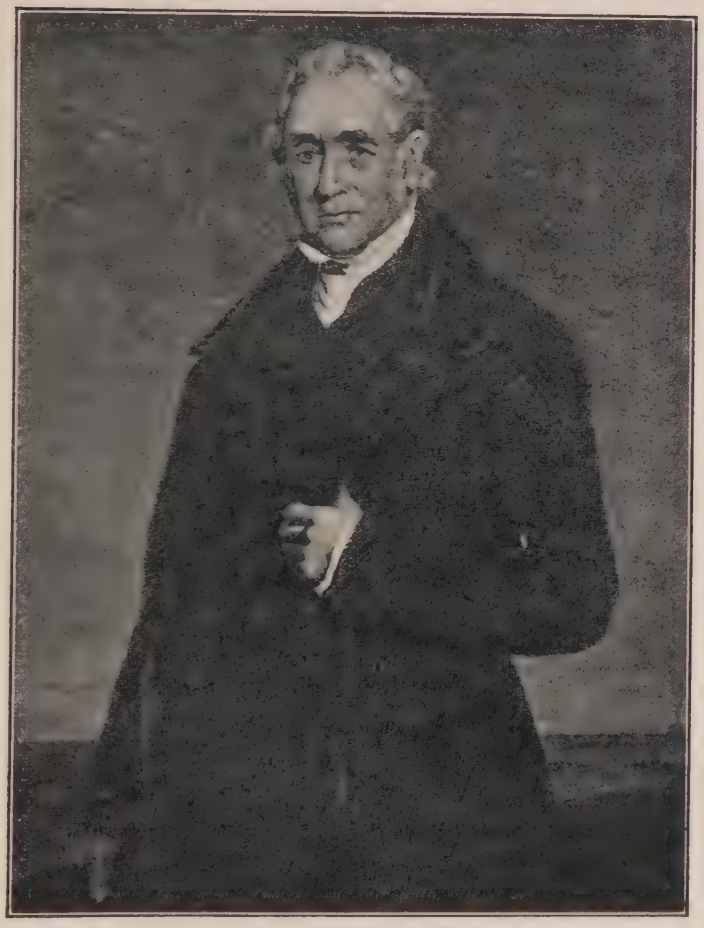
The inventor drove it to the harbor and shipped it to London, where he exhibited it. But in those days the roads were poor, and after a short time he

gave up driving it, thinking that no steam locomotive would be a success on account of the bad roads. No one had yet thought of laying a special track for an engine.

Meantime, a young man named George Stephenson, who was working in a coal mine near Newcastle, was studying out a new kind of locomotive. George was born in 1781, and had lived the life of the other boys of the village. He had been a herdboy for the cows of a neighbor; he had been a "picker" in the coal works, taking out stones from the coal. But George had risen from helper to fireman, and from fireman to engineer.

Stephenson moved to a new house on the River Tyne, where coal was shipped to London. Here he married and made his home in a small cottage. His work was to run a fixed engine that drew train loads of coal cars up a hill. He spent a great deal of time on his plans for a steam engine that would draw coal cars. Stephenson had seen locomotive engines like the dragon which was built by Trevethick, and had declared that he could build a better one.

After studying all the engines he could observe, Stephenson told one of the mine owners of his plans for a new "traveling engine," as he called it. Money was furnished him to build such a locomotive. In ten months he built the "Blutcher" engine, which proved to be the most successful working engine that had yet been built. It would pull eight loaded wagons of about thirty tons weight up a slight grade on rails at the rate of four miles an hour.



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GEORGE STEPHENSON

This engine was used for some time, but it was a clumsy machine. Having no springs, it jolted so hard that it soon injured the rails on which it ran and

shook the machinery apart. So Stephenson set to work to make a better one.

His first engine allowed the steam to escape into the air with a loud, hissing noise, which frightened horses and cattle and was a nuisance to everybody around. He thought that he might pipe the steam after it had done its work into a chimney or smoke-stack, where its exhaust would drive the air up the chimney and make a better draught for his fire. He tested this idea and was delighted to find that it made his fire burn better, and he could therefore make steam faster. The invention of the steam blast was a great improvement in the locomotive.

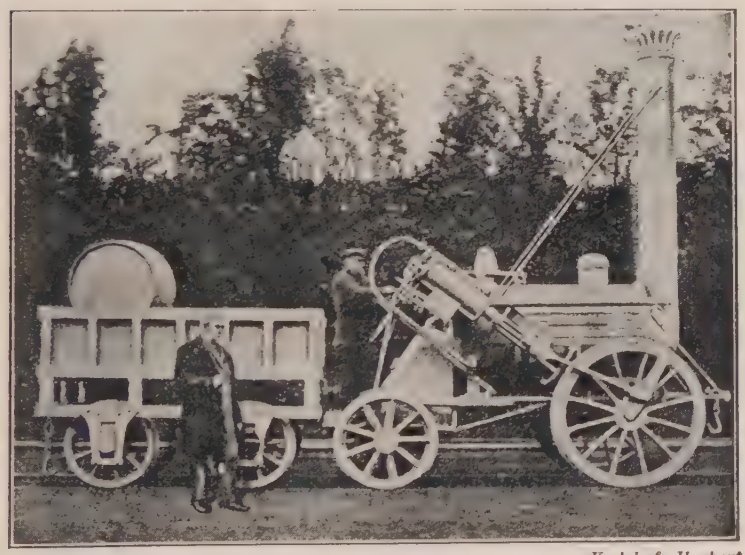
So with this new idea he started to build his second locomotive, making many other improvements. It had fewer parts, and the power was applied more directly to the wheels. Completed and patented in 1815, this locomotive, with its added power gained by using the waste steam as a blast in the chimney, was the model used in all locomotives for many years.

Realizing that the road and the rails were almost as important as the engine, Stephenson paid more attention to the proper joining of the rails. He used "half-lap joints" in laying new rails. That is, instead of "butt joints," or placing the ends together, he lapped the ends over each other. Upon these the locomotive ran much more smoothly. To save his engine from the jolting that ruined his first model, he put on a system of springs.

This new locomotive, called "Puffing Billy," was so very efficient in pulling coal cars at the mines that

Stephenson's friends urged him to look into the matter of making a locomotive for traveling on the common roads. By this time Stephenson's son, Robert, was old enough to help his father. For a time Robert worked in the mines, but later his father sent him to college. A few years after this we find Robert also succeeding as an engineer.

It was not long till other mines began to build rail-



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STEPHENSON'S *Rocket* MADE IN 1829

roads to do away with horse-drawn cars. In 1822, one mining company built a railroad eight miles long and bought five of Stephenson's locomotives for use on it. The road ran in part of its course through hilly country where the grades were steep, and it was neces-

sary to use fixed engines in certain places. The locomotives traveled over the level stretches at four miles an hour, drawing seventeen coal wagons weighing about sixty tons.

So successful was the locomotive in hauling coal that it was soon planned to build a longer road in another part of England to carry freight and passengers. Everywhere Stephenson met men who opposed the railroads. The farmers said they had no wish to have a "Puffing Billy" racing through their fields and frightening their cattle. One member of Parliament publicly poked fun at Stephenson.

"Suppose," said the objector, "one of these engines were going along a railroad at the rate of nine or ten miles an hour, and a cow were to stray upon the line and get in the way of the engine. Would not that be a very awkward circumstance?"

"Yes," answered Stephenson, with a twinkling eye, "very awkward—for the cow."

One of the lords who was fond of hunting said, "Nothing could be more distasteful to me than to hear the echo of hissing engines resounding through the hills, or running through the heart of our hunting country. It would destroy our sport."

Another said he would rather meet a burglar on his premises than an engineer. Some physicians objected and said that it would make passengers ill to travel through tunnels. Other scoffers pointed out the constant danger of exploding boilers.

However, the road was built. When the line was completed, a great celebration was planned. Thou-

sands of people gathered to see the opening of the first public railroad. Stephenson himself drove the engine with a train of thirty-four cars carrying coal, freight, and four hundred and fifty passengers. The train made the first nine miles in an hour and five minutes. By the time the train reached the end of the line, there were six hundred people riding in the cars or hanging on to them as the train puffed along from four to six miles an hour.

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THE TWENTIETH CENTURY LIMITED

It was not long till many of the people who could afford it were traveling by rail. Still the noblemen held out against this new fad. They did not like to ride in the same cars with all classes of people. They had always traveled in private, horse-drawn coaches.

For a time they sent their luggage and servants by rail, while they jogged along the country roads in family carriages. In 1842, however, Queen Victoria went by rail from London to Windsor. Then the noblemen gave up their snobbish notions and followed her example.

Stephenson was busy for years building railroads and improving his locomotives. His advice was much sought by inventors and business men. He had coal mines of his own and became a wealthy man for those times. The story of his great work of making railroads a success will be read and enjoyed by boys and girls all down the ages.

Questions and Problems

1 What is a stationary engine? A locomotive?
2 Why did Trevethick's locomotive fail?
3 Why was the "Blutcher" engine more successful?
4 What was still needed to make a real success?
5 What is a steam blast in the locomotive and what good results from it?
6 How are the rails of a modern railroad jointed together?
7 How did the first railroads overcome steep grades?
8 How can a railroad engine climb Pike's Peak?
9 Why did the nobility of England at first refuse to ride on a railroad train? Would Americans have felt the same way? Why or why not?

CHAPTER VI

FRANKLIN'S FAMOUS EXPERIMENT

OF all the subjects ever studied by men of science, not one has been found more interesting than electricity, and none means more to the world to-day. Yet for many centuries very little was known about it. Finally, a Frenchman, Du Fay, discovered that there were two kinds of electricity: one kind that is made by rubbing glass with silk, which it called positive; the other by rubbing sealing wax with flannel, called negative. The two kinds always attract each other.

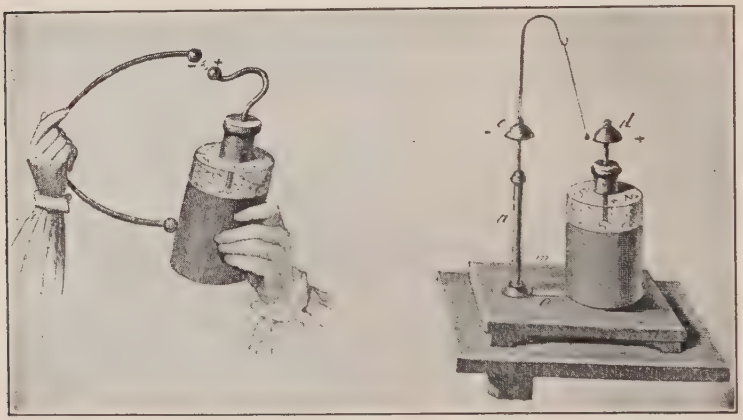
Soon after this it was discovered that two kinds of electricity exist in all electrical bodies and that rubbing simply separates them. One kind is never produced without the other.

Then a certain professor at Leyden invented the Leyden jar, in which large amounts of electricity may be stored and kept. The Leyden jar is simply a glass bottle or jar coated with tin foil both inside and outside. When it is charged with electricity, the jar will hold its charge until the two coatings are connected by a metal wire or some other good conductor of electricity. A man may receive a severe shock by holding the jar in one hand and touching the knob connected to the inner coating with the other hand.

While experimenting with the Leyden jar, the inventor received an electric shock which frightened him. He declared he would not undergo another such

experience for the crown of France. But he soon got better control of the "wonderful bottle," as people called it, and after a while it became quite the fashion for people to take an electric shock, and the jar became popular as a plaything.

Then Ben Franklin became interested in this strange power called electricity. He began to study



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THE LEYDEN JAR

and experiment, and soon came to believe that electricity was not created or produced by friction or in any other way. Franklin said electricity was present everywhere and that every body contained some of it. He believed that every body contained more or less, and he introduced the words *positive* and *negative* to indicate this condition.

Franklin made a battery of Leyden jars by connecting the inner coating of one to the outer coating of the next, and so on with several jars. In this way he

could get a much stronger spark than with a single jar. On one occasion Franklin nearly lost his life by taking a shock from his battery of Leyden jars.

But Franklin's greatest discovery lay in his experiments with lightning. What is lightning? The Dakota Indians believed that lightning was a spark which flashed from the "cloud bird's" track, just as sparks were caused when a buffalo scampered over a stony plain. Thunder, the red man said, was the noise made by the flapping of the "cloud bird's" wings. According to other myths, lightning was a firebrand hurled down to earth by one of the gods. When people outgrew such ideas as these, they were still at a loss to explain the nature of lightning.

At the beginning of the eighteenth century, the common belief among scientists was that lightning is caused by the rapid burning of some kind of gas in the clouds. Benjamin Franklin was the first person to give us a correct answer to this question.

In 1746, while in Boston, Franklin saw some electrical experiments which interested him very much. At that time the cell for generating a current of electricity had not yet been invented, and the experiments which Franklin saw were with electricity made by friction.

Franklin soon obtained the necessary apparatus and repeated for himself some of the experiments which he had seen. He was able, by means of an electrical machine, to produce long sparks of electricity. It occurred to him that these sparks resembled lightning in many ways. Could it be possible that lightning was only a huge spark of electricity?

The more carefully Franklin observed, the more convinced he became that lightning and electricity are one and the same thing. In 1749, he published a list of the ways in which he thought the two were alike. "The electrical spark," he wrote, "is zigzag, and not straight; so is lightning. Pointed bodies attract electricity; lightning strikes mountains, trees, spires, masts, chimneys. Electricity chooses the best conductor; so does lightning. Lightning destroys animal life; so does electricity when powerful." The thunder, he reasoned, might correspond to the crackling noise caused by the spark of electricity.

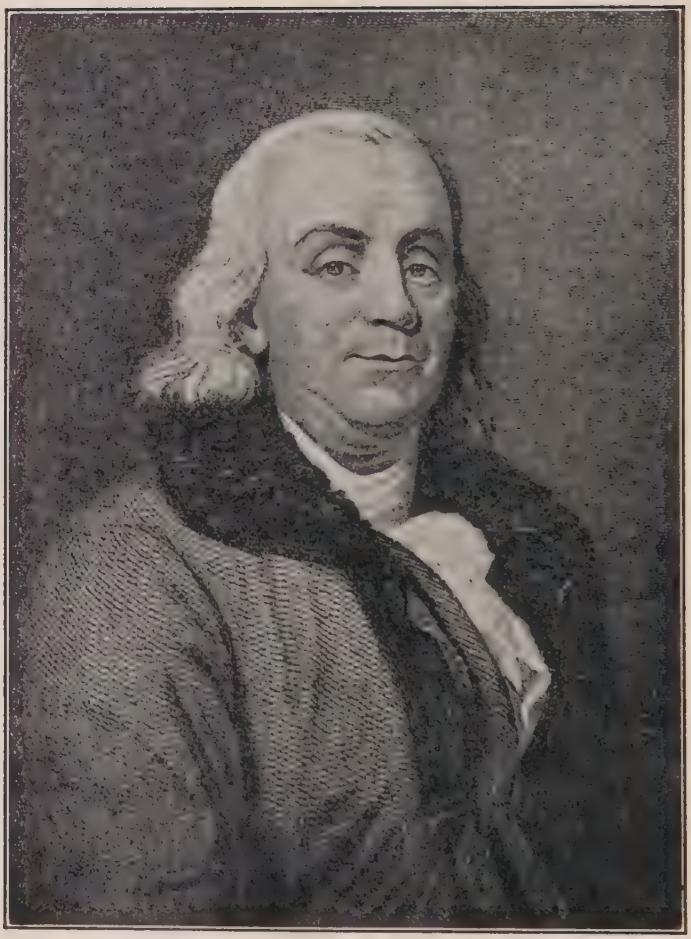
To account for the fact that lightning was infinitely more powerful than any spark which he could produce in his laboratory, he wrote, "If two gun barrels, electrified, will strike at a distance of two inches and make a loud snap, at what great distance may ten thousand acres of electrified cloud strike and give its fire, and how loud must be that crack?"

Many scientists thought his explanation a reasonable one, but Franklin was not satisfied until he could offer some proof that he was right. He immediately began to plan an experiment. He argued that clouds must be charged with electricity and that this electricity might be drawn off from the clouds by points. To try this, he thought at first it would be necessary to build a tower or a steeple high enough to reach up into the clouds. To raise the money for the tower, he and his friends went about the country giving lectures about electricity and performing experiments.

While Franklin was doing this, two Frenchmen

LIGHTNING

succeeded in getting sparks from the lower ends of tall, pointed rods during a thunderstorm. Although this seemed to prove the identity of lightning and electricity, Franklin contended that, since the rods



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BENJAMIN FRANKLIN

were less than a hundred feet tall, and therefore could not reach the clouds, these rods might have been electrified in some other way. However, this experiment suggested to him that there might be an easier way of getting electricity from the clouds than by building a tall tower.

In 1752, the idea of using a kite occurred to him. To carry out his new plan, he made a kite of silk and put a small piece of wire at the top. To this kite he tied a hempen string. At the lower end of the string a metal key was fastened. He also tied a silk ribbon to the end of the string. If his theory were correct, electricity from the cloud would come down the string and he would be able to draw sparks from the key. He would hold the kite by the ribbon, since silk is a very poor conductor of electricity, and would not allow the current to flow through his body into the ground.

Franklin eagerly awaited an opportunity to try out the apparatus. When he saw a thunderstorm approaching, he and his son went into an open field where they stood under a shed for shelter. He sent up the kite. The first cloud passed and nothing happened. The second cloud approached. Soon Franklin noticed that the fibers of the kite string appeared to bristle up and move back and forth. He held his knuckle near the key and a small spark jumped from the key to his hand. It began to rain and the cord got wet. It was then a much better conductor, and Franklin was able to get much longer sparks from the key.

Franklin brought up a Leyden jar and charged it with electricity from the cloud. He found that with

this charge he could do everything that could be done with electricity from his machine. Thus he had proved that lightning and electricity are the same thing.

When Franklin's paper on his experiments was read to the Royal Society of London, the wise mem-

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Franklin's Printing Press

bers greeted it with sneers and laughter. But there were other men of science in Europe who were eager to believe in Franklin's new discoveries.

The results of this experiment attracted world-wide attention. Perhaps the most remarkable feature of it was that Franklin was not killed, because of the high voltage of electricity. Less than a year later,

another scientist was killed while trying to repeat Franklin's experiment in Leningrad, Russia.

The experiment, besides winning fame for Franklin, stimulated interest in electricity. Many new experiments were performed which finally led to the discovery that electricity was not merely an interesting plaything, but a great force which could be harnessed to do man's work.

Questions and Problems

1 How could you make the two kinds of electricity?
2 How do these two kinds behave toward each other?
3 What is a Leyden jar?
4 How did Franklin prove lightning and electricity to be the same?
5 How do lightning rods protect property?
6 What good came from Franklin's experiments?
7 Place a piece of glass under each of the legs of a chair. Let a boy or girl then sit in the chair with feet on the rungs. Stroke him on the shoulders several times with a silk cloth or a piece of fur. Then place your knuckles close to his nose or ear.

CHAPTER VII

ELI WHITNEY AND THE COTTON GIN

THE busy life of Eli Whitney began in Massachusetts in 1765. His father was a mechanic as well as a farmer, and what was unusual in those days, he had a complete set of tools of his own. There was also a lathe for turning the parts of furniture.

Eli liked these tools. Had he been in school to-day, he would have been interested in manual training work. But then he did not care for school or his books, except his arithmetic. When he was quite young, he could repair violins and do other fine work. Eli says that one Sunday while his parents were at church, he took his father's watch to pieces and put it together again so successfully that the father did not know it. He sharpened knives and put in new blades. He could make nails and was really a wonderful mechanic for the times.

People did not go far from home in those days, but Eli made a journey. Needing a helper in the shop, he went to hunt one who was skillful. On the way he learned many things, for he was quick to see how things were done and could imitate what he saw.

When Eli was twenty-three years old, he decided to enter college and went to Yale. Here by hard work he made good in his studies, but his deep interest was always in machinery. One day he mended some apparatus in the laboratory so well that he attracted

the attention of his teachers. To-day he would have taken honors in the engineering department, but then there was no opportunity in college for the man who worked with his hands, so he decided to teach.

Young Whitney secured a school in South Carolina and set out for that state, but when he reached there he found the salary so small that he could not afford to take it.

Back of every inventor we find a benefactor who, with friendship or money, has helped the inventor to succeed. In this case it was a woman. On the boat going south Whitney met the widow of General Nathanael Greene, who took an interest in the young school teacher and invited him to her home. Here he was given an opportunity to read law and to meet Mrs. Greene's friends, who were men of wealth and influence in that state. Many of them owned cotton plantations.

In conversation with these men Whitney learned that they were all anxious to plant more cotton, but they said there was no profit in the crop because it cost so much to take the seeds from the lint. This work was done by slaves. It took about ten hours' work to remove three pounds of seed from a pound of lint.

Whitney was much interested in the problem, and Mrs. Greene said to her friends: "You should have a machine to do the work, and here is a young man who can make you one. He is very clever, for he has mended everything on my place."

A few days later Whitney sent for a boll of cotton.

He pulled the clinging seeds from the lint with his fingers. They clung so tightly that he wondered how any one could have the patience to separate them. A roller gin was already in use that pulled the seeds

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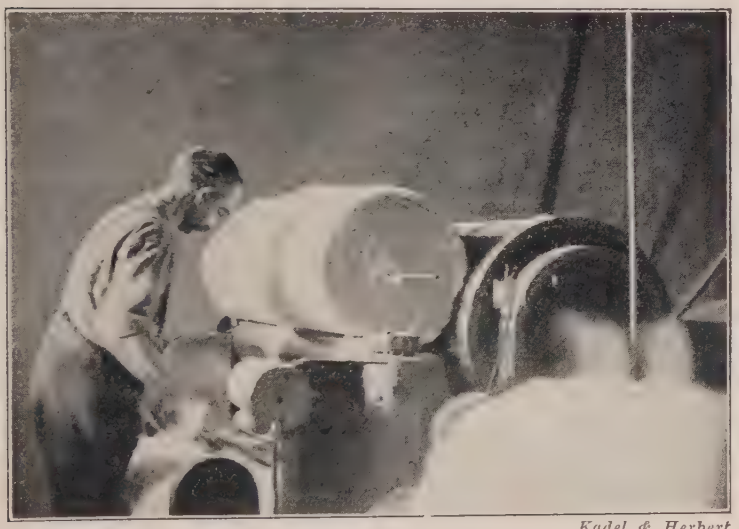
COTTON INDUSTRIES

from the cotton that had long fiber, but the cotton fiber of this region was short, and the roller gin could not be used.

The young man set to work in the basement of Mrs. Greene's beautiful southern home to invent a machine. He tried the plan of pushing the lint through slits so narrow that the seeds would be broken off; but the lint soon piled up and got in the way.

"You should have a brush to clear it away," said Mrs. Greene, and she offered him the one she used on her hearth. Acting on this suggestion, Whitney arranged a rotary brush which would sweep the lint from his machine into a box. Little by little he overcame all obstacles, and by spring Eli had a model gin



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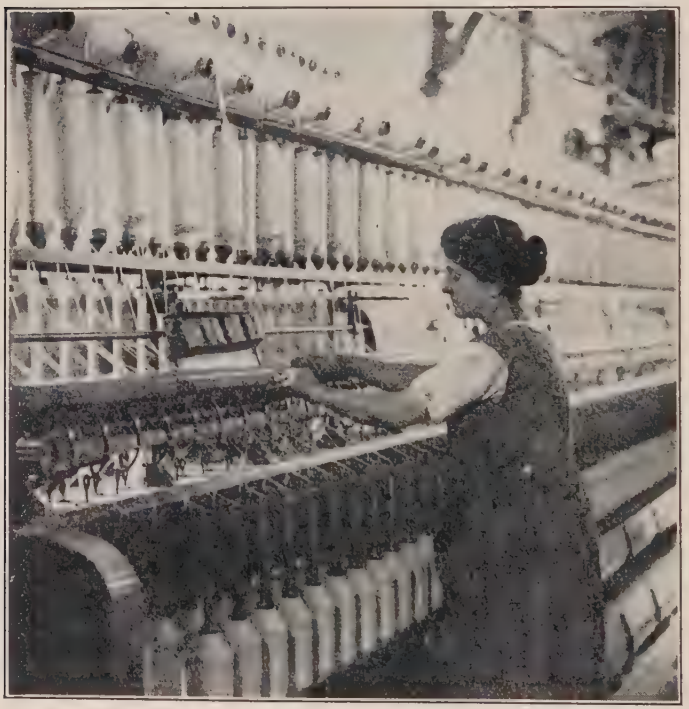
TURNING THE RAW COTTON OUT IN A BROAD ROLL OR "LAP"

which he turned by hand and successfully cleared the seeds from the cotton.

Mrs. Greene invited her friends from far and near to see the invention. They urged Whitney to patent his machine, and Phineas Miller, who afterward married Mrs. Greene, agreed to provide the money if Whitney would give him a half interest. The patent was issued in 1794.

It took more money to launch the enterprise than Miller expected. They borrowed funds and completed the machine for market, but they could not protect their patent. Dishonest mechanics all through the



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THE COTTON SPINNING DEPARTMENT

country copied Whitney's machines and sold them. For several years Miller and Whitney fought to protect their rights, for hundreds of machines were in use and they were not profiting from the sales.

One of Whitney's enemies had him cast into prison

on a false charge. Miller, worn out with the struggle, died in 1803, and Whitney had no money to continue the conflict for his rights. When he appealed to Congress to protect his patent, he was refused.

His invention had supplied just the thing the cotton industry in the South needed, and the planters were making immense profits. Hundreds of hands were employed in picking cotton. The spinning jenny and the power loom were invented to make cotton cloth, which lowered the price of the goods and increased the demand for cotton.

When Whitney saw there was no hope of profiting by his invention, he resigned himself to his fate and decided to do something else. He began to manufacture firearms. In 1797 he was making muskets for the United States Army. In 1812 he was given a contract by the government for fifteen thousand stands of arms.

In 1816 Whitney married the daughter of a noted man, but he lived only nine years to enjoy his family. He was a kindly man and much beloved by his friends.

He did not have the reward in money that he should have had while he was living, but to-day we give him all honor for a great gift to progress. If Whitney were alive to-day and could visit the vast cotton fields of our country and the great factories busy weaving cotton cloth, perhaps he would feel repaid in knowing that his work has been a great good.

Questions and Problems

1 What is a lathe?
2 Why was Whitney sure to be an inventor?
3 Why were cotton planters in trouble?
4 What is meant by securing a patent?
5 What was the spinning jenny? The power loom?
6 Do you think the government should have protected Whitney's patent?
7 What effect did the cotton gin have on the South? On slavery? (Refer to your history.)
8 Before the days of cheap cotton what was clothing made of?
9 What is linen made from?

CHAPTER VIII

ROBERT FULTON AND THE STEAMBOAT

AFTER the success of Watt's steam engine, it is surprising that so many years passed before this engine was yoked to a boat or ship. On every sea boats and ships were becalmed for days together, because there was no wind for their sails. Then again they could make but slow progress or none at all, because the wind was blowing a gale against them.

There were several steamboats invented about the same time, but it was left for Robert Fulton to make a successful one and put it to use.

Robert Fulton was born in Pennsylvania in 1765, ten years before the American colonies broke away from England in the war for independence. When Robert was three years old his father died, so the lad received but little education. When ten years old he told his teacher, "My head is so full of my own ideas that there is no room for the storage of dusty books."

At the age of thirteen Robert wanted to celebrate the Fourth of July with candles in the windows, so he made candles for this purpose. But as the weather was very dry, the village fathers requested the people not to use candles for fear of fires. Robert then sold his candles and bought powder and paste-board to make skyrockets. The merchant, who had never heard

of skyrockets, asked what the lad was going to do with powder, and when he had his answer, he said: "Tut, tut! That's an impossibility."

"No, sir," said Robert, "there is nothing impossible."

As Fulton grew to manhood he loved to draw, and as he lived near Benjamin West, the artist, he often visited him. Fulton soon moved to Philadelphia, where he earned his living at the easel. He also studied engineering. We later find him in England where he studied steam engines, and later still in France, busy inventing a torpedo. In 1800, Fulton built his first diving boat, or submarine, the *Nautilus.*

The next year he built an improved boat. Fulton and a sailor shut themselves in with a single candle and remained under water twenty minutes, after which they came up amid the applause of thousands of spectators. This submarine, also called the *Nautilus,* could fire a torpedo while under water.

At this time Napoleon of France was at war with England, and the British fleet was blockading the French coast. Napoleon offered Fulton 60,000 francs if he would torpedo and destroy a British warship of ten guns. If he blew up a vessel carrying more than thirty guns, he was to have 400,000 francs.

For a whole summer the inventor pursued one British warship after another with his *Nautilus.* Once he almost hit a seventy-four-gun vessel, but she escaped. Since he failed, he received no reward and, worst of all, the French navy lost interest in his torpedo.

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ROBERT FULTON

Fulton then went to England where he showed his invention to the officials of the government. Mr. Pitt, the prime minister, remarked that these weapons could destroy every fleet in the world. To test his invention, Fulton blew up with torpedoes a heavy old ship lying on the water near Mr. Pitt's castle with only seventy pounds of powder. The explosion lifted the ship almost bodily and broke it in two.

But when Mr. Pitt died shortly afterward, Fulton lost his best friend, for the next prime minister was not interested. The British government finally asked the inventor if he would sell his inventions to England and let the government suppress them, but he refused, saying, "My own country may at some time have need of these inventions, and I would not sell them to you for twenty thousand pounds a year."

Fulton's plan of control of torpedoes and other devices led to the models in use to-day.

All these years Fulton had in mind the building of a steamboat. In 1763, while he was yet a young man in Pennsylvania, his neighbor, William Henry, invented a steamboat and made it run on one of the rivers near by, but it was soon wrecked. About the time Fulton went to Europe, this inventor died.

Among the friends of William Henry was a skillful mechanic named John Fitch, who in 1786 launched a small boat or skiff on the Delaware River, propelled by oars which were moved by a steam engine. A few years later Fitch launched a steamer propelled by a screw.

One day John Rumsey, while riding along the Dela-

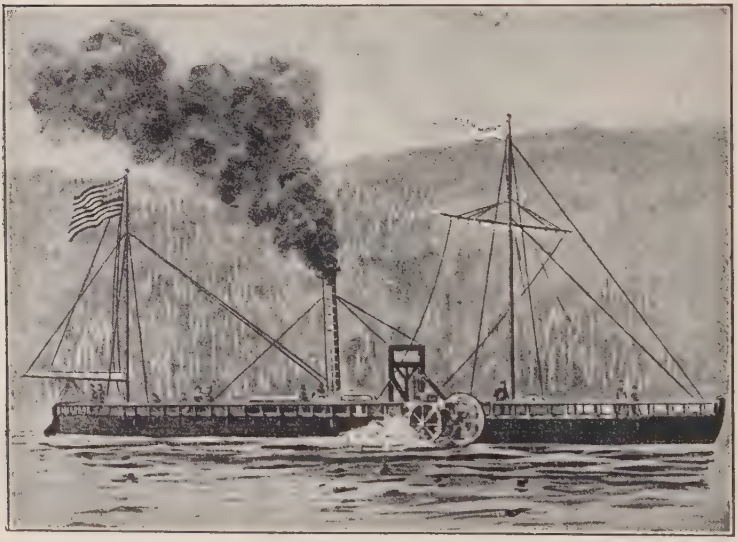
ware, saw the little steamboat of John Fitch and resolved to build a better one. After much experimenting, he built a steamboat in 1804, and the following year a second one that had many new points. One of these boats made eight miles an hour, and both had screw propellers like modern ocean vessels.

All this time Fulton was in Europe and did not know about these American steamboats. In 1803, he built a little boat on the Seine River in France. But no sooner had he brought on board the machinery to run her than she broke in two and sank. Fulton raised the machinery and built another and stronger boat that made four miles an hour. The people of Paris, however, were not interested, and the boat was not used.

Fulton again went to England where he saw a better steamboat than his own, built by Synington. He had a ride on this English boat and made some notes about its construction.

Fulton then selected and bought an engine suitable for a steamboat and ordered it to be shipped to America. He set sail for home in 1806. Arriving in New York, Fulton and his friend Livingston engaged a shipbuilder to build a steamboat after the drawings which he had made. But before it was finished they ran out of money. They had trouble finding people who would risk a loan on such a foolish thing as a steamboat. At length they got the necessary money from men who asked that their names be kept secret, because they did not wish to be ridiculed by their friends.

Those who saw Fulton's boat while it was building doubted if it would ever run. It was called *Fulton's Folly.* Fulton often loitered unknown near the idle group of strangers gathered to make sport of his boat. They ridiculed it and laughed it to scorn, and estimated the money he was throwing away. Not one good wish or bright hope did they utter.



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THE *Clermont*

The boat was at last finished and named the *Clermont,* after Livingston's estate on the Hudson.

The *Clermont,* launched and equipped, was to leave New York on Friday, August 11, 1807. A crowd of people thronged the water's edge with eyes on the strange-looking vessel. They were all ready to laugh

at her failure. Presently the big side-wheels began to turn, sending spray flying on all sides, and the *Clermont* was off. When the crowd saw her successfully head up stream, they rent the air with cheers. Not one felt like scoffing now.

Only twelve people took passage for Albany that day. Few men wished to trust their lives to this queer craft with a puffing demon inside. On the banks of the Hudson above the city were many people gazing at the strange sight. At every town the banks were crowded; hats and handkerchiefs were waved while the people cheered.

The *Clermont* passed many sailing vessels on the river. The crews of these vessels gazed in astonishment to see the water monster pouring smoke and sparks into the air, churning the water into a foam and moving against the current without sails. Some flung themselves in terror on the decks of their vessels, while others took to their boats and rowed lustily for the shore. It was still worse at night. The voyage was the sensation of the time and was long remembered.

The *Clermont* covered the one hundred and fifty miles to Albany in thirty-two hours, and returned in thirty, making about five miles an hour. She then made regular trips, and the steamboat was proved a paying venture.

For a while no steamboats but those of Fulton were allowed to run on the Hudson.

Before his death in 1815, Fulton had built seventeen boats, among them the first steam war frigate, the first torpedo boat, and the first steam ferryboat.

Questions and Problems

1 How long did it take the *Mayflower* to sail across the Atlantic?
2 Tell about Fulton's submarine.
3 What do you know of William Pitt? What town in America is named for him? Why?
4 What were some of the problems that Fulton had to solve in building his tiny submarine?
5 Tell of other men's steamboats.
6 What is meant by *Fulton's Folly?*
7 How was the *Clermont* propelled?
8 Are ocean vessels propelled the same way to-day?
9 What can you say of the *Clermont's* wonderful speed?

CHAPTER IX

JOHN ERICSSON

AMONG the cold lakes and dark forests of Sweden, there was born, in 1803, a baby named John Ericsson. Many years later this lad was to emigrate to the United States and make a name for himself as an inventor. As a child he was familiar with the dark and gloomy forests of his native land and the thin hard soil where it was difficult for the people to make a living from their poor crops.

But down beneath the forests in the mountain sides were vast deposits of iron ore. The mines offered to these people another way to earn a living. As his father was part owner of a mine, John took his only chance for an education in studying the machinery at the mine and foundry. He was an industrious boy. When only nine, John loved to draw. Having only a quill and a pencil, he made a drawing pen out of some steel tweezers. Then he robbed his mother's fur coat of enough hairs to make a small paintbrush. All day he worked with his pencil and drawing tools on odd pieces of paper, making drawings of the machines.

When John was eleven years old, his father moved a hundred miles away from their mountain home to help build a great ship canal for his country. John was filled with wonder as he saw the great engineering work going on before his eyes. From any one who would talk to him, he learned all he could. He was

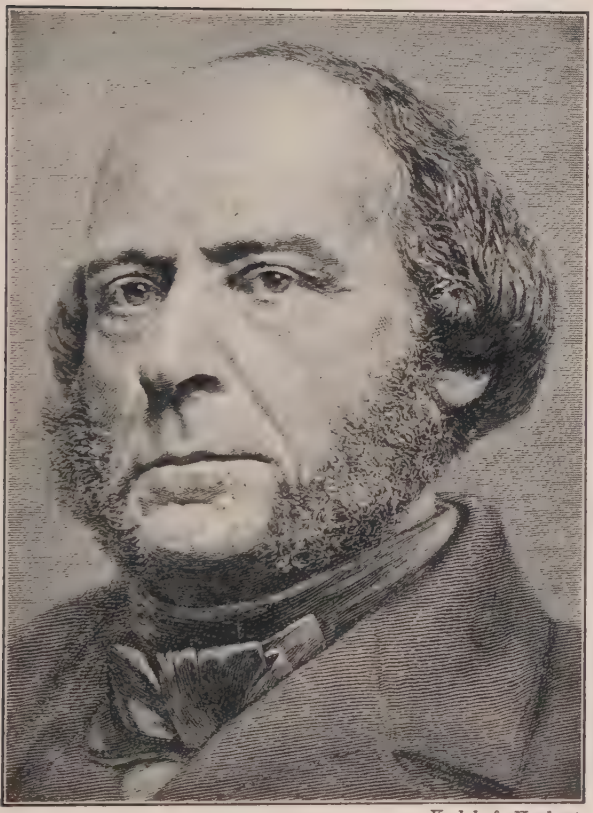
taught to draw excellent maps by a boarder in his home. A friendly teacher guided him in learning to draw houses. John also studied chemistry until he could make his own inks and colors.

At the age of twelve, the lad used his pencil so well that he was asked to make some drawings for the canal company. The next year this led to a good position with the company, making plans for the canal.

In his leisure hours, John found pleasure in building small working models of machinery. At the age of ten, he had made a toy sawmill which, many years later, was considered his first invention. This model was built entirely of wood except the band saw which was filed out by hand from a broken watch spring. The saw was run by a crank made of an old tin spoon with a cord for the driving band. When water was turned into the water wheel, the machinery ran perfectly.

His father having died, John saw that he must help support his mother. So he joined the Swedish army to earn money. He was now seventeen, a fine, powerful fellow. In the army John studied diligently and was promoted rapidly. In a short time he was looked upon as an expert in artillery.

After a time Ericsson grew tired of army life and longed for better chances than his homeland offered, so he went to England, where engineers were then thought to be doing great things. However, the steam engine was yet only a toy and electricity a mystery.



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JOHN ERICSSON

It was in the year 1819 that the first steam-driven ship crossed the Atlantic, and this great event stirred Ericsson to new efforts. He had for some years been working on new kinds of engines and ways of improving boilers. He invented and built, in 1829, the first

steam fire engine, which for many years was relied upon to fight city fires. But for a long time this helpful invention was not used. Some said it was of no practical value.

The steam locomotive was not yet a proven invention. In 1829, a prize of twenty-five hundred dollars was offered for the best steam locomotive which could draw a weight of twenty tons at the rate of ten miles an hour. Ericsson had never built a locomotive, but he entered the contest. His greatest rival was George Stephenson, who for several years had built small locomotives for use in coal mines.

On the great day of the contest, thousands of people gathered along the track to witness the strange sight. Stephenson named his locomotive the *Rocket*. It was a strong, well-built engine. Ericsson's locomotive was a worthy invention called the *Novelty*. The race was on. Amidst the excitement the *Novelty* passed the *Rocket* at the amazing speed, for those days, of thirty miles an hour. But before the goal was reached the *Novelty* broke down, and Stephenson's *Rocket* won the prize. While Ericsson was fairly beaten his spirit was not overcome.

Ericsson then turned to work in a new field. Up to this time the sailing ship with its widespread canvas had ruled the seas. Robert Fulton had used the steam engine to propel vessels on rivers by paddle wheels attached to each side of the vessel. These side-wheels were huge and awkward, and so easily damaged by ocean waves that they could not be used on the sea.

Ericsson designed in 1835 a screw or rotary pro-

peller driven by steam for ocean vessels. Since it operated under water, the huge ocean billows could not harm it. Ericsson placed it underneath the stern of the vessel, just forward of the rudder, where it is used to-day. The Surveyor of the Royal Navy was hard to convince. He said that even if the propeller screw had the power to propel the vessel, it would not work; because when it was placed under the stern, it would be impossible to steer the ship. But all ships are to-day using this propeller just as Ericsson planned it.

To test his new invention, Ericsson built a small vessel and launched it on the Thames River in the spring of 1837. The ship with its screw propeller ran at a speed of ten miles an hour, to the amazement of all who looked on. No bystander could see what drove it forward. But the Englishmen were very slow to take up new things. They could not see that the invention would change all ocean-going vessels. It was years before England decided to adopt the screw propeller which is used everywhere to-day.

In the next year, Ericsson built and launched a larger vessel named the *Robert F. Stockton,* which sailed from an English port and, after a successful trip, landed in New York City. It was the first screw-driven steamship to cross the Atlantic. Some American friends then persuaded Ericsson to come to America where new inventions were more welcome.

There were no steam vessels in our navy when Ericsson reached our shores. Within two years he built for our government the *Princeton,* a small, iron

warship. It had not only the screw propeller and a new type of gun carriage designed by the inventor, but a cannon reënforced by steel hoops shrunk on the breech of the gun. A similar method of making cannon strong is now used in all high-powered guns.

The *Princeton* was a new type of warship. She was speedy for those times, and had her machinery below the water line out of danger from enemy guns. Her screw propeller and her powerful guns made her the talk of naval men the world over.

In 1844, Ericsson was free from worry over money, for his receipts in this year from his inventions and contracts were about forty thousand dollars, which was a large income in those days. In 1848, he became a naturalized citizen of the United States, and thus we can claim him as one of our own great American inventors.

When war began between the North and South in 1861, Ericsson took sides with the Union. The United States navy was then composed entirely of wooden ships and all were in great danger, for the navy of the South at once began building floating batteries heavily protected by iron sides. They took the frigate *Merrimac* and covered her sides with iron plates, so that the cannon balls of those days would not harm her. She was also fitted with an iron prow for ramming wooden ships.

Ericsson laid before President Lincoln his plans for a new type of ironclad warship which he called the *Monitor*. He was given a contract to build it at once. The *Monitor* was constructed with great haste and

was afloat in three months. Unlike other warships, the *Monitor* had a flat deck and rested so low in the water that only about three feet of her sides could be seen. The sides and decks were protected by heavy iron plates. In the center of the deck was a round, iron-covered turret twenty feet in diameter, containing two powerful guns which revolved. Thus the *Monitor* was a small target hard to hit and harder still to harm. Any shot that might strike her would glance off harmlessly. The revolving turret enabled

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THE *Monitor* AND THE *Merrimac*

her crew to fire her big guns in any direction without turning the vessel. The ship was operated entirely by steam engines placed well below the water line and was driven by a screw propeller.

The *Monitor* was built at the Brooklyn navy yards.

It had been planned that she should serve with Admiral Farragut's fleet at New Orleans, but a crisis was at hand near at home. The South, in order to cut through the wooden fleet that blocked entrance to her ports, had begun to use her ironclad vessels. The *Merrimac* was not only covered with an iron roof and side plates but was armed with heavy guns.

On the afternoon of March 8, 1862, the *Merrimac* attacked the Union fleet in Hampton Roads, and easily sunk and destroyed two wooden warships. Thinking that enough for one day's work, she confidently steamed back to Norfolk to return the next day and finish the job. The ships of the North were at her mercy and their men expected the worst on the following day. If these Southern ironclad ships could sink the Union ships so easily, they would break up the blockade, and the war to save the Union might be lost.

But when the *Merrimac* returned the next morning to finish her work of destruction, she was met by the *Monitor,* this queer-looking little craft which had arrived from New York during the night. The enemy called her a "cheese box on a raft," because she was so small. It seemed like the fight of a pygmy and a giant.

For several hours the two strange ships fought like demons, each circling the other, with black smoke pouring from their funnels and the red flame of the great guns spurting from gunports. The anxious eyes of thousands of soldiers and sailors on shore and on ships awaited the outcome.

The *Merrimac* again and again fired her biggest guns at her smaller enemy, but the cannon balls glanced

off harmlessly. Unable to harm the *Monitor* with her guns, the *Merrimac* next tried to ram her, but the *Monitor* was too agile and dodged easily, all the while firing her huge guns at some weak spot in the larger ship. Finally the *Merrimac* withdrew from the battle and steamed back to Norfolk, leaving the *Monitor* as the victor.

The *Merrimac* never returned to renew the battle. Ericsson's "cheese box on a raft" had saved the Union fleet, which continued to blockade the southern ports until the war was over. This first fight of ironclads completely changed naval warfare throughout the world, as it proved that no wooden ship could stand before an ironclad.

With the close of the war, Ericsson continued to give his best thought to the building and mounting of heavy guns. In later years great honor came to him, not only from the United States but from Sweden and Denmark, from Spain and Austria. He spent his wealth in serving others. The story of his life of work and service will inspire the boys of all time to deeds of usefulness.

Questions and Problems

1 What do you think of Ericsson's education?
2 In what way did the skill in drawing aid Ericsson?
3 How did John's experience in the army aid him in later years?
4 What was a steam fire engine? How are the fire engines of your city propelled? Why not by steam?
5 Describe the contest between Ericsson and Stephenson.
6 How does the screw propeller serve ocean vessels better than side wheels?
7 Why do not river steamers use the screw?
8 What enabled the *Monitor* to defeat the *Merrimac*?

CHAPTER X

McCORMICK AND THE REAPER

A HUNDRED years ago inventors in England and Scotland were working on machines that would cut grain. Many harvests were lost because harvesting with the scythe and sickle was so slow.

In 1786, William Pitt invented a machine that clipped the heads off the grain. It had a reel like the frame on which fishermen dry their nets, which pressed the grain against the cutters. This machine was pushed ahead of the horses.

The Bell reaper was likewise invented in England in 1831. It was a crude machine but successful, and a few were sent to America. In 1851 six models were exhibited in New York. Mr. Bell's machine was also pushed ahead of the horses. One man drove, eight men collected the cut grain into sheaves, four men bound the sheaves, and two others set them up in stacks to dry. Fourteen people besides the driver of the machine could harvest twelve acres a day. This was slow work indeed compared with the work of the excellent harvester of to-day.

Cyrus McCormick was a lusty farmer lad, who hated the hard work of the harvest season. He was born in Virginia, which state at that time had the greatest wheat crop of any in the United States. Cyrus was big and strong, but the cradle which they

used to cut wheat seemed so needlessly heavy and clumsy that he made a lighter one for his own use. At this time he was only fifteen. He also worked to improve his plow and other tools he used. Doubtless his fellow workers called him lazy and shiftless because he was not contented to work as they did.

"We should cut all this grain with a machine," declared young Cyrus.

"It can't be done," said his father; "I have worked years on such a machine, but I found it would cost a fortune to manufacture it. Besides, it would always be out of order should it be finished."

"They are doing it in England," persisted young Cyrus.

"Well, go ahead," said his father. "You can't tell a young chap anything. Take the old machine I failed with and see what you can do."

Cyrus knew that one of the things standing in the way of the success of his father's invention was that it would not cut tangled grain. When this machine came among stalks of wheat which did not stand firm and straight, it stopped cutting.

Cyrus put at the end of the knife of his machine a curved arm to throw back the row of grain as it fell. The knife was a series of steel blades the shape of triangles bolted together. Two edges of the blades were sharp, and the whole knife moved back and forth like a saw so as not to miss a stalk of wheat. The grain was led to the knives by a row of fingers at the edge of the blade. When the grain was leaning, it was lifted straight before cutting by a revolving

reel. The cut grain fell upon a platform which was part of the machine. All parts of the harvester were run by driving wheels which received power from the motion of the reaper and sent it on to the other parts of the machinery.

International Harvester Co.

THE MCCORMICK REAPER OF 1821

Cyrus tried his invention first in his father's own field. To his great delight, it lifted and cut the tangled grain nearly as well as the straight. He next set out to cut a six-acre field of wheat for a friend while the neighbors looked on. Cyrus drove the

reaper and slashed down the crop in one afternoon with only his machine and a team of horses.

"It would have taken six men to do that work with cradles," boasted his father. "Son, you have made a success of my failure."

But the next year when the machine was brought to demonstrate before a large group of people, it acted very badly. The field was uneven and rough, and Cyrus had not much to say for the results.

"Give the boy a fair chance," called one of the men. "You can't expect a machine to work on a hill. Here's a level field over the fence. Try it here."

The owner consented to the experiment. The rail fence was taken down and the machine cut all the grain in the field before dark.

But, like other inventions, it took Cyrus many years to get a market for his machine. It cost a great deal to manufacture reapers and few farmers could afford to buy them.

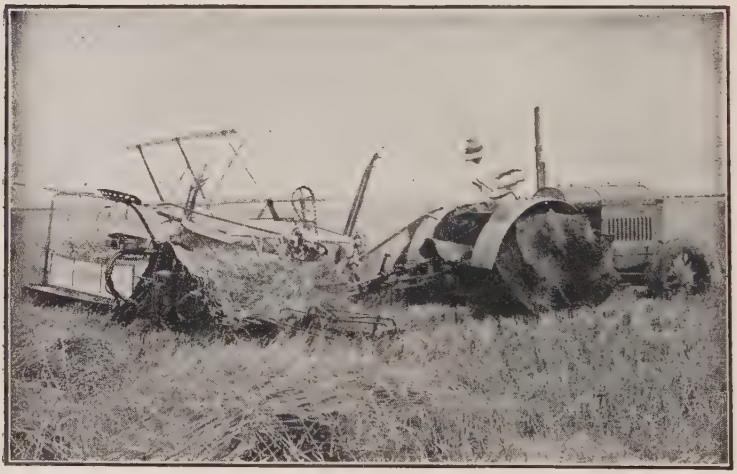
"I cannot afford money for a machine when I can get men for so little to harvest my crop," said one farmer after another.

Cyrus took out a patent and worked hard to get money to advertise. Meantime Obed Hussey, a man from Baltimore, also took out a patent on a reaper. Both machines were good, having many things in common.

Cyrus worked nine years before he really sold a machine. The first one brought fifty dollars and helped to sell two others. By this time he had discovered that his machine did not work well when the

stalks of the grain were damp, so he set up a shop and worked out a new, saw-toothed blade that would cut more successfully.

He had no trouble in selling his machines in Virginia; but when he began to get orders from the Mississippi Valley, he did not know how to deliver his machines for they were so heavy. There were no



International Harvester Co.

McCormick-Deering 10-20 Tractor Pulling a McCormick-Deering Binder

railroads, and it took months to send them by water through the Gulf of Mexico and up the Mississippi River.

McCormick made a visit to the mid-west and saw the vast grain fields. Some were being pastured to horses and cattle because there were not men enough to harvest the crops.

"I must build the machines where the grain needs cutting," said Cyrus.

Chicago was only a village in 1847. It was not a promising place then, but McCormick knew that most of the grain was shipped to the east from this point, so he built a factory in Chicago. In this city he gave many demonstrations of his machine, and offered the farmers credit until they could pay for them with the profits of their harvests.

By this time there were many firms manufacturing his machine and the patent had run out. Congress would not renew it because the manufacturers banded together to prevent it.

"I must add something to my machine for which I can have a new patent," said McCormick, so he added the binder. Until now the grain had been raked off the platform in bunches and then bound into sheaves by men. The self-binder neatly tied the sheaves into bundles. Wire was used for binding until Manila twine was found to work better.

To-day we have the complete harvester which cuts the standing grain, threshes it, winnows it, and places it in sacks. On one side of this great combination of binder and thresher is a long cutting bar sometimes twenty-five feet long, which cuts down the wheat. On the other side of the machine there pours forth a stream of clean grain which runs into sacks. Men with wagons or motor trucks gather up these sacks and carry them to the nearest market.

This great harvester was drawn by thirty or forty horses until the gasoline or steam tractor came into use. It can cut and thresh a hundred acres of grain

in a day at a cost of fifty cents an acre. The harvester has enabled farmers to raise larger and larger crops until on single ranches there are thousands of acres in grain. Thus McCormick's harvester has made it so much easier and cheaper to harvest wheat that it has brought down the price of bread for us all.

Questions and Problems

1 What was peculiar about the Bell reaper?
2 Tell what you can of the sickle and the cradle for cutting grain.
3 Tell of some of the problems Cyrus had to solve.
4 How does the knife of McCormick's reaper work?
5 How did he take care of the tangled grain?
6 Why did McCormick set up his factory in Chicago? Did he show good judgment? Why or why not?
7 Find out what you can of the modern harvester.
8 What are grain elevators? What city is noted for them?
9 Name the chief wheat-growing states.
10 What is the difference between whole-wheat bread and white bread?

CHAPTER XI

ELIAS HOWE AND THE SEWING MACHINE

ELIAS HOWE was a bright young man who earned his living in a machine shop. He had only small wages, and his wife had to work long hours with her needle to clothe the children. At night while he rested, she sat and stitched that the family might be neatly dressed.

Elias Howe thought of all the mothers in the world who toiled with the needle and wondered how they could be saved that endless stitching. If he could only make a machine that would push the needle back and forth through the cloth, what a blessing it would be!

Howe began to experiment with a machine. At first he used a needle that was sharp at both ends with the eye in the middle. The thread had to be very coarse and strong or it would snap. He decided he must make a different stitch than that made by hand so he used two threads, one in a curved needle and the other in a shuttle, forming a lock stitch. In 1844, he had invented a machine that would work, and had made a model in wood and wire.

But now Howe must advertise his invention. He believed he would soon have a fortune if he could show what his machine would do. So he moved his family to his father's house and gave up his job in the machine shop.

But he had no money to make machines. A man in Cambridge took an interest in the model. He offered

to go into partnership with Howe, and said he would provide a home and board for Howe's family and advance him five hundred dollars to build a machine to show to the public. All this he agreed to do for a half-interest in the patent.

Howe worked almost day and night that winter. In April he had a machine that would sew a seam four yards long. He had a contest with several people sewing by hand. Howe stitched five seams while they sewed one. But when he tried to sell the machine, all the tailors objected to it because they thought it would injure their business. At that Howe's friend refused to help him further, so he had to move his family back to his father's home.

Howe then became a locomotive engineer; but his health broke down and being forced to do something else, he went back to his sewing machine. His brother took the machine to England and interested a man who offered twelve hundred and fifty dollars for it. He also offered Elias work in his umbrella and corset factory.

So Elias moved his long-suffering family to England. Here they almost starved. Elias found his new master very disagreeable and finally they quarreled and parted. Howe's people sent him enough money to bring his wife and children back to America while he stayed in England, still hoping to interest people in his machine. Discouraged at last, he decided to return. He pawned his patents to get money enough to reach home. When he arrived in New York, he received word that his wife was very ill

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ELIAS HOWE

in Cambridge. It was many days before he could get enough money together to go to her. He reached her bedside just before she passed away.

Thus one misfortune after another came to the inventor, Howe. While he was mourning the loss of his wife, he awoke to the fact that while he was in

England some one had stolen his idea and was making and selling sewing machines in the United States. He employed patent lawyers, and after a long, hard fight established his rights to his invention in 1854.

By this time many people were interested in sewing machines. A few owners of factories bought them, but the workmen went on a strike and destroyed them as soon as they were installed. This did not last long. Soon all people who could afford sewing machines began using them in their homes. The machine sewed a seam much firmer and stronger than any that could be sewed by hand, and the opposition to them died away. Women who had worked far into the night sewing found how much time they could save with a machine.

In the end Howe was paid for all his machines. In one year his royalties grew to two hundred thousand dollars. His sewing machine was awarded a gold medal at the Paris Exposition in 1867. We are glad to know that this patient inventor had a few years of honor and reward before he died in Brooklyn, where he made his last home.

Questions and Problems

1 What moved Elias Howe to invent a sewing machine?
2 What were some of his problems?
3 Examine a sewing machine to see how the stitch is made.
4 Why is it that inventors' families so often suffer want?
5 In what way did Howe fare better than Whitney?
6 What is a sweat shop? Why did they not have them a hundred years ago?
7 What are the chief kinds of sewing machines?

CHAPTER XII

THE GAS ENGINE

THE power used to run most automobiles and airplanes to-day is obtained from gas engines. In all such engines we get power by explosions something similar to those of firecrackers on the Fourth of July. In the gas engine we do not explode gunpowder but a mixture of gas and air.

Would you like to know where we got the word "gas"? In the old books on chemistry we find this story: The philosophers of the Middle Ages were troubled by explosions which they could not understand. When they brought fire in contact with certain contents of vessels which they could not see but were experimenting with, there was a terrible explosion. Since they could not understand the reason for it, they said the explosion was caused by the presence of some evil spirit. A Flemish chemist called it "geest," meaning a ghost or spirit. From this we derive the word "gas."

Because gas engines are lighter in weight and take up less room, they are superior to the steam engine for many purposes. We find them not only in automobiles and flying machines but they are used in factories of many kinds. They also furnish power for churns, plows, tractors, and all sorts of machinery on the farm.

Cannons are the oldest gas engines. Gun powder took the place of gas and air, and the cannon ball was the piston. When the powder exploded, it created the gas that fired the ball.

In the seventeenth century when men sought power to do their work, they thought of the power to be had from powder explosion. Some man with a liking for invention made a powder engine, but he could not control it. So the idea of a gun-powder engine was abandoned for more than a hundred years.

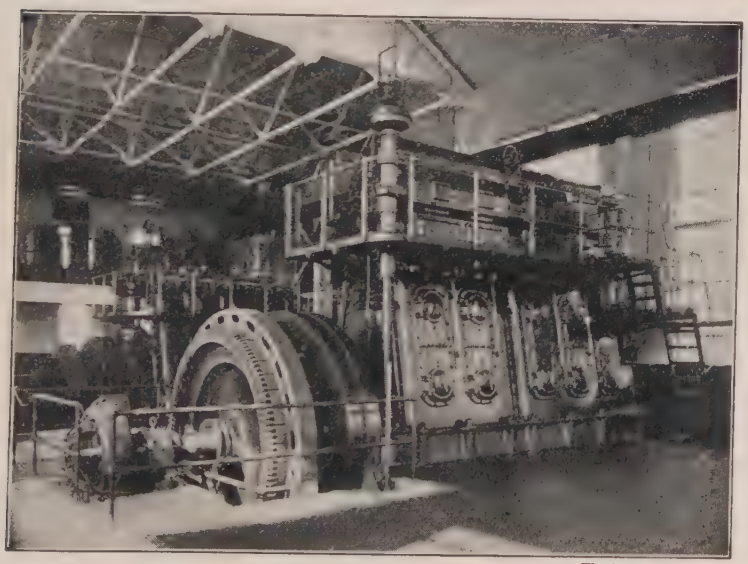
Then near the close of the eighteenth century coal gas was discovered, and this led to a new interest in the gas engine. John Barber, an Englishman, built the first actual gas engine. He used a gas distilled from wood, coal, or oil. The gas, when mixed with the proper portion of air, was let into a tank which he called the exploder. The mixture was fired and came out in a continuous flame against the blades of a paddle wheel, driving them around with great force.

A little later a French engineer proposed to compress the mixture of gas and air before firing in order to get greater power. He further proposed to fire the mixture with an electric spark just as it is done in gas engines to-day. But as he was about to make this great improvement he lost his life, and as he was the only man of his time with the idea, the gas engine had to wait for another genius to get the vision.

Another Frenchman named Lenoir invented the first working gas engine in 1860. From this time on it developed rapidly. A gas engine can be made much lighter than a steam engine of the same power. The

automobile and the airplane require very light engines. Without the gas engine the automobile would have remained either very clumsy or very costly, and the airplane would have been impossible for want of a light yet powerful engine.

In 1876 two German inventors, Otto and Langen, brought out a new engine of the kind called four-cycle. It is so called because the piston makes four strokes for every explosion. There is one stroke to



Kadel & Herbert

THE DIESEL ENGINE

admit the mixture of gas and air to the cylinder, and another to compress the gas and air. At the beginning of the third stroke the explosion takes place, and in the fourth stroke the burned gases are driven out

of the cylinder. Later engines were made with six, eight, and twelve cylinders. In the story of the submarine you will also learn of the Diesel engine.

In a steam engine the power is applied at every stroke, but in the four-cycle gas engine the power is applied to the piston only in one stroke out of every four. So it would seem that a steam engine would do more work than a gas engine with the same amount of fuel, but this is not the case. In fact a good gas engine will do about twice as much work on the same fuel. The reason is that a steam engine wastes its heat through the boiler surface and the pipes, while a gas engine applies the heat of the explosion directly to the piston. When a gas engine is at rest there is no fire; no heat is used, yet the engine can be started very quickly.

A steam engine is easier to start. The engineer has only to turn the steam into the cylinder, and the engine begins to move. But the gas engine has to be turned by a crank or a starter until at least one explosion takes place; for until there is an explosion of gas and air in the cylinder, there is no power.

Even though the airplane was invented in America, our government had done very little before the war to develop its use either in commerce or as a fighting craft. When we entered the war we asked our allies what we could do to help, and their answer gave us a shock.

"Airplanes!" they cried. "Build us airplanes quickly—thousands of them—so that we can drive our enemies out of the air and blind their armies!"

We had a reputation throughout the world for making things in big quantities, and now we must do quickly and on a large scale something we knew very little about.

In the first place it was plain that the heart of an airplane was its engine. We knew a great deal about gasoline engines, especially for automobiles, but an airplane engine is a very different thing. It must be exceedingly light. Every ounce of weight that can be spared must be shaved off. It must be built as carefully and accurately as a watch.

There was no time to waste, for our allies were hard pressed and almost ready to give up the fight. A motor had to be designed that could be made rapidly by machinery. Two of our best engineers met in a hotel in Washington on June 3, 1917, and worked for five days without once leaving their room. They had before them all the airplane knowledge of our allies. All makers of engines in America gladly sent in their secrets, and everything was done to make the greatest airplane engine in the world. There was a race to have the motor finished by the Fourth of July, so the Liberty motor could be presented to the nation as a birthday present. It was done.

But since so much had to be planned by way of making special machinery to produce the new Liberty motor, it was Thanksgiving Day before the factory was ready to make the first motor. They were to be made in quantities. Even after that there were many slight changes to perfect the engine.

The Liberty motor was not altogether new, but rather it combined the good points of all other gasoline engines and was remarkably efficient. It weighed only 825 pounds and developed over 420 horsepower. It proved a great success, and our allies sent us large orders for the Liberty motor for use in all heavy airplanes and in seaplanes. Thus the Liberty motor had its part in winning the war.

Questions and Problems

1 Where did the word "gas" originate?
2 In what way could a cannon be called a gas engine?
3 What led to greater interest in the gas engine?
4 What was Barber's exploder? How did it work?
5 Compare a gas with a steam engine.
6 What is meant by a four-cycle engine?
7 What do you know of steam-driven automobiles?
8 Tell about the Liberty motor.

CHAPTER XIII

THE AUTOMOBILE

MEN had long wished for better and quicker means of travel than the horse could provide. Sir Isaac Newton in 1680 invented a toy horseless carriage. Later, as we have read, the steam engine was tried in a wheeled vehicle on the public roads and streets in England, but it was found too heavy for the rough highways. Still inventors continued to work on the problem and to make trials with rude contraptions.

The people of England had so little regard for the horseless carriage that until 1896 they had a law which forbade automobiles to speed at more than four miles an hour, and the law further required that a man waving a red flag should precede every power-driven vehicle along the streets. It was only twenty-five years ago that a man was arrested for daring to drive an automobile in Central Park, New York City.

The earliest automobiles were built for pleasure. They looked like a single-seated buggy made of wood and were propelled by a noisy, one-cylinder engine. They were gradually improved, as sheet metal and aluminum were substituted for wood, and the bodies were made on more artistic designs. The one-cylinder engine gave way to those of two, four, six, eight, and even twelve cylinders. The greater the

number of cylinders the smoother the engine runs and the more power it has.

The first automobile race in America was run in 1895 at Chicago. Two cars started on a ninety-mile course, but only one finished. It took eight hours and forty-eight minutes of puffing and clattering to reach the goal. During the race this machine stopped ten times for repairs. It made an average speed of ten miles an hour. Cakes of ice were used to cool the engine.

There were three very important aids to the development of the automobile. The first of these was the gas engine which we have read about. It was invented about twenty years before the real beginning of the automobile. The Otto Cycle gas engine first used in 1876 is found in the greatest number of motor cars to-day. The important new idea that it introduced was to get the most power; the gas and air mixture should be compressed before it was exploded in the cylinder. Advantages of the gas engine for motor cars are the small space required for it, the light weight of the engine, and the fact that no boiler is needed. Because the fuel is burned in the engine itself there is no waste to dispose of.

Another advantage of the gas engine is that the fuel is plentiful and easy to carry. It was fortunate that gas or petrol was already known, and that it was cheap. In the treatment of crude oils obtained from wells many products were obtained that were much wanted. Some were solids like paraffin wax; others liquids, such as lubricating oils and kerosene, which was much

used for lamps in the days before electricity. But least useful at that time, except for cleaning, was gasoline or motor spirit. Now the interesting fact is that in making oil for lamps, for fuel, and for lubricating, one cannot help making gasoline. So gas was cheap and ready for use in an engine, and it had this added advantage that with it the engine could be started at once without waiting to be heated up as was the case with a steam engine. Therefore a cheap fuel at hand helped greatly in the development of the gas engine and the motor car.

Another aid to extending the use of motor cars was the rubber tire. The earliest cars used only solid tires. Bicycles used pneumatic or air-filled tires in the early days, but no one thought such tires could be made strong enough or safe enough for the heavy loads of motor cars. But since the roads were then rough, motor cars with solid tires could not travel very fast and they were not comfortable. Neither could they draw such heavy loads. The use of the pneumatic tire on automobiles made them much more comfortable.

The motor car could not have developed so rapidly had not the makers of steel given their aid. The cars had to be light in weight, and so all the steel parts had to be made lighter and stronger to keep down the weight. Thus a study was made of steel alloys to produce mixtures that combined lightness with enormous strength. The use of aluminum has played its part also in decreasing the weight of motor cars.

At first an electric battery was used to explode the

gas, but this plan had its drawbacks, for the battery had to be recharged frequently. Then the Germans developed the magneto for exploding the gas, which was a great improvement. After a time, however, people wanted their cars electric lighted, and electric starters were also needed. Since the magneto would not do this, the battery was again introduced and has been so much improved that it is now in general use. In order to keep the battery properly charged cars had to have an electric generator, and an electric motor was also needed to turn the engine over until an explosion of the gas could be made.

Then an oiling system was developed to lubricate all bearings before high speed cars could be possible. Bearings soon become hot unless constantly oiled, and the engine may be burned out.

To transmit the power from the engine to the rear wheels, chains were used in early cars, but chains have given way to a propeller shaft which is geared to the rear axle. The differential gear allows the engine to turn the rear wheels at different speeds in turning corners.

Detachable rims did away with tire repairs on the road. Tires were improved so as to reduce the number of punctures or "blow outs," and non-skid tires were introduced to prevent skidding and side slipping of the wheels.

Motor trucks carry products to country districts, making homes there desirable. The motor car and the motor truck are every year extending their aid to sections not reached by the railroad. The rail-

roads lost much freight traffic that passed to the motor truck. The trucks used the public roads and, for a time, escaped the burdens of road upkeep and of heavy taxes. For this reason the trucks could carry goods at less expense than railroads.

Motor roads can be constructed for a less cost than the railway. Thus by building motor roads a new country can be quickly developed. A network of good roads and the use of the motor truck will soon reach all remote districts and connect them with the rest of the world by rapid transit.

The motor truck displaces horse power because of the greater distance it can travel in a day. Perishable goods like fruit, vegetables, or meat can reach a wider market.

Motor service need not injure the railroads, but may be used as aids by reaching out from a railway point. Railroad companies are more and more using trucks to cover outlying districts. Every year multiplies the number of trucks; all countries have progressed rapidly because of their aid.

Along with its increasing usefulness in peace the automobile reached a wide use in war. It made it possible to move men and supplies on a scale that was formerly thought to be impossible. In the first German drive on Paris in 1914, the French moved sixty thousand troops forty miles by automobiles in a single night and struck the Germans a surprise blow which drove them back and saved Paris.

The motor car also developed into the tank which, by laying its own track as it went, helped to break the

German lines of defense and to force the enemy to beg for peace.

But best of all are the touring cars which have afforded recreation to thousands of families of small income. Every year people travel many miles for pleasure and business with little expense. Beautiful cars have been built with every luxury for those who can pay for them. Country people enjoy the pleasures of the city and city dwellers drive to the country for picnics and rest. In every land millions of miles of hard, smooth roads have been built for automobiles.

The motor car to-day is the work of many minds and the product of many financiers who have risked their money to produce a perfect automobile that will bring happiness and education to every one.

Questions and Problems

1 Why did the first horseless carriage fail?
2 What is the objection to a one or two cylinder engine in an automobile?
3 Describe the first automobile race.
4 What are the advantages of gasoline over other fuels?
5 Why is electricity needed in a gas engine?
6 In what two ways may the spark be supplied?
7 How did rubber help the automobile industry?
8 What is meant by steel alloys?
9 Compare a battery with a magneto for automobile use.
10 Why did the motor truck largely drive horses off the city streets and roads?
11 Explain the use of the tank in the World War.

CHAPTER XIV

GOODYEAR AND RUBBER

RUBBER is so commonly used to-day that we can scarcely imagine how men could live without it. The Spaniards who first came to South America found the natives there playing with balls of solid rubber. The explorers found that if they rubbed the juice of the tree from which this rubber ball was made on their clothes, it would make them waterproof. In that tropical country of many rains this knowledge was very useful.

Some of the natives molded water vessels of the dried juice of the rubber tree and even clumsy boots which would keep out water. About a hundred years ago a sea captain brought some of these rubber shoes or gum boots, as they were called, to New England.

In 1823 a Scotchman named Mackintosh discovered a process of placing a sheet of rubber between two layers of cloth. Rubber coats and shoes were being made in America in 1834; they were much in demand for wet and cold weather. But when the hot weather of summer came, the people who owned these expensive garments found they became soft and useless.

The manufacturers of rubber goods were in despair, for their products not only grew soft and sticky in hot weather but in cold weather they became so hard that

they cracked. It was declared that the man who could discover a way to make rubber safe against heat and cold would gain a fortune, but no one believed it could be done.

Charles Goodyear, a hardware merchant in Philadelphia, one day bought a rubber life preserver and took it home. He was much interested in life preservers. Goodyear declared that many lives would be saved in accidents on the water if the ship's furniture was all made of rubber filled with air.

Goodyear's father had been an inventor of tools, and Charles was also much given to improving things. He worked out some new ideas for the rubber life preserver and took them to the manufacturers, but they would risk no money to test them. Goodyear had no money, but he then and there resolved to find the secret of preserving rubber.

Shortly after this Goodyear's business failed, and he was thrown into prison for debt. Here he had much time to think of his problem. His friends provided him with small quantities of rubber with which he experimented. When he returned home he used his wife's oven to heat his product. He flattened it with her rolling-pin. He got her up at night to jot down some of the discoveries he worked out in the midnight hours. Having no laboratory, his experiments took many years. When he worked out something in cold weather, he was obliged to wait for summer to test his success and more often than not it was a failure.

Neither did Charles Goodyear know anything of chemistry, so he went on working blindly, trying one

thing after another to improve his rubber. His family was often without food and sometimes with hardly a shelter. It is said he once sold his children's schoolbooks for five dollars to get funds for his experiments.

Goodyear bought several barrels of gum elastic and spread it on cotton. From this his wife made garments. He made hundreds of pairs of rubber shoes, but when hot weather came they all melted down and he had to begin again.

One day he left his barrels of gum open and his stupid helper applied it to his own trousers, hoping perhaps to make them waterproof. In a few moments his legs were cemented together and he was glued to his chair. Goodyear used a pair of shears to cut the prisoner free, but the experience taught him something new about his rubber.

The inventor kept working at a process to turn the surface of the rubber so it would not stick. He consulted all the chemists he met, but no one could help him. He was much ridiculed because he wore the rubber clothes his wife had made from the fabrics he created. When he was seen on the street clad in rubber coat, rubber cap, and rubber shoes, the children called after him, "Rubber! Rubber! Rubber!" Even his friends tapped their heads as he passed, indicating that he was losing his mind. But he kept on with one experiment after another. He pawned everything he had and then borrowed money from his friends, gathering brush wood from the fields to keep his fires going.

One day Goodyear made a rubber fabric and was

Goodyear Tire & Rubber Co.

CHARLES GOODYEAR

trying to decorate it by bronzing the surface with paint. He found the paint too heavy, so he tried to remove it with an acid. This acid removed the bronze, but discolored the cloth so that he threw it aside. Several days later he happened to pick it up again and found that the rubber would stand the heat much better than before.

The inventor at once got a patent and induced some friends to help him set up a rubber business. But shortly it was discovered that the acid only hardened the surface of the rubber hats and shoes and coats, and that the rubber would actually bear heat no better than before.

Now the inventor's family and his friends tried to prevail upon him to earn a living some other way. His wife took to selling the linen from her loom, which in that day was looked upon as the extreme of poverty. She was ready to do anything to encourage her husband to persevere. Goodyear borrowed wherever he could, and went on. His health failed, but still he worked day and night.

One day the inventor was trying sulphur mixed with rubber gum when some of it fell on a red-hot stove. This piece he afterward found could not be melted by heat. He hung it out in the cold all night. The cold did not affect it. He was overjoyed.

Building upon this discovery, he toiled on year after year until he had worked out successfully the whole process of vulcanizing, which consisted of mixing the gum with sulphur and heating the mixture to the melting point much as it is done to-day. The name "vul-

canizing" was given to the process from Vulcan, who was the god of fire.

Goodyear worked out one experiment after another and patented them until he had sixty rubber patents in the United States. But he never received the

The Goodyear Tire and Rubber Company, Akron, Ohio

reward in money that he should have had for his labor. He spent his last years fighting for his rights and striving to regain his health. Honors finally began to come to him, and he lived to see his rubber used in hundreds of different ways and saw thousands of people employed in rubber factories which was made possible by his inventions. But he died, at the

age of sixty, a poor man after all his sacrifices.

With all the uses of rubber, perhaps the pneumatic tire is the most important product of the rubber industry. With the coming of the automobile and the bicycle, immense rubber factories grew up in the United States. When pneumatic tires supplanted the

Goodyear Tire & Rubber Co.

GATHERING RUBBER ON THE GOODYEAR PLANTATIONS

solid tires used on carriages and bicycles, the sale of rubber tires became a great business in every city.

Rubber is obtained from the milky juice or latex of certain plants and trees found in the tropical regions. Along the equator in South America and other tropical countries are trees called *hevea* which yield great quantities of rubber. The juice is collected by

the natives and brought down the Amazon River to be shipped to the United States.

The rubber collectors search the jungle for trees about two feet in girth. They are tapped in the dry season. An incision is made in the bark and cups are placed for collection of the sap. A number of cuts are made in the same tree and in a few hours the cups are filled. Then a fire is lighted and palm nuts which contain acetic acid and creosote are placed in it. The native dips a kind of paddle in the sap and holds it in the smoke of this palm nut, and the rubber hardens. When the first layer is firm, another layer is added by dipping it in the sap again and holding it in the smoke.

When the crude rubber arrives at the factory, it is purified of foreign matter by steeping it in warm water containing soda. Then it is cut into small pieces by revolving knives and passed between steel rollers which makes it into an uneven surface, thin and flat, called *lace*. During this process it is washed and washed again. Then the lace is dried in heated rooms and finally mixed with sulphur and heated or vulcanized—which is the Goodyear process.

So important is the rubber industry to-day that all nations are much interested in lands that are suited to rubber plantations. Whoever controls the rubber and oil producing lands will have a great advantage in case of war. Nations are therefore eyeing one another with jealousy on account of these products that are so important to civilized people in times of peace and war.

Questions and Problems

1 What was Mackintosh's discovery?
2 What was the great problem to be overcome in the use of rubber?
3 What qualities has rubber that make it so valuable in modern life?
4 Did Germany find a substitute for rubber when her supply was cut off during the war?
5 Where does the rubber tree grow?
6 Tell about Goodyear's failures.
7 How did he finally succeed?
8 What is sulphur and where do we get it?
9 Name all the uses for rubber you can.
10 What processes are needed to make rubber?
11 What cities are noted for rubber works?

CHAPTER XV

THE WRIGHT BROTHERS AND THE AIRPLANE

FOR ages men have watched the birds circling so easily above their heads and have longed for wings of their own that would skim the air. Some experimented with kites, others with balloons. A German inventor built wings like those of a hawk, and after casting himself off the peak of a mountain he reached the earth safely. But he continued to glide until at last the wings broke in mid-air and let him fall, and he gave his life to his experiment.

From time to time men made flying machines which would sail through the air for a short distance, but the currents of air or the winds changed so suddenly that all the machines sooner or later capsized.

One man tried to meet these sudden changes by shifting the position of his body to balance the machine, but the time came when he was not quick enough and he also lost his life. Langley at last built a heavier-than-air machine with many new features that was used in successful flight.

Wilbur and Orville Wright, who successfully solved the problem of flying, were brothers living in Dayton, Ohio. Their father was a scholar and a teacher and their mother a college graduate; thus they came of a thinking family. The mother died before these two

boys could be sent to college, so they set up a bicycle shop and went into business.

Once when the boys were seven and eleven years of age, their father brought home a clever toy that flew by itself around the room for some time. The boys were much interested and named it "the bat." They had great sport with their plaything and studied the principle on which it was built. Perhaps it was

An Early Biplane

this little toy that turned their attention to flying; perhaps it was because the world was thinking of it.

The Wright brothers took note of all the failures of others and the reasons for them. They adopted many of Langley's ideas and others that were practical. They worked in their little shop making model machines while they tried to discover a way for an airplane to right itself when the wind changed. "Air currents," they said; "shift without warning. The wings of our plane must shift as quickly as they."

So the brothers built a machine with wings or plane ends that would warp or bend with the wind. These flexible ends might be shifted or bent up or down by the changing currents of air. If a gust of wind tilted down a plane end, the warp on that side of the plane was drawn down and the effect was to raise it back to position. A system of control cords made the machine balance. When one wing warped down, the other moved up and balanced the machine. These plane ends acted of themselves, automatically, just as do the curving, bending movements of a bird's wings.

The Wrights first sent their machine up like a kite with a rope holding it steady against the wind while the pilot tried out the balancing tests. They had two helpers to get them started in the air, one at each end of the machine. The helpers ran forward with the plane until it had enough motion, and then let go when the great plane soared into the air.

These inventors made runners on the bottom so the machine would not stop too suddenly upon lighting but glide over the ground to a gradual stop. They preferred the double wings or biplane, because this type could be made strong and compact.

The Wright brothers wanted a place to practice where the velocity of the wind was about twenty miles an hour. They chose a sandy beach at Kitty Hawk, North Carolina, where the wind came in from the Atlantic Ocean. Two seasons they practiced at Kitty Hawk with a glider plane.

Having reached this stage, they were ready to add their engine. They built this on the plan of those

used in motor cars, only lighter. It was a four-cylinder engine of twenty-five horse power and weighed about twenty-five pounds. In the first flight the new machine stayed in the air almost a minute

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ROUND-THE-WORLD FLIERS REACH NEW YORK EN ROUTE TO SEATTLE

during which time the brothers flew quite a distance in a straight course. They found they could start and stop without danger and had their plane well under control, but when they tried to turn in the air, they came to grief.

In a swampy meadow near Dayton the Wrights practiced for many months, but they worked so quietly that few knew of their progress. They invented a propeller which was successful; in time they had their machine adjusted so they could turn, and at last in 1904 they made two flights of three miles each in a circle.

In 1908 they announced to the Aero Club of America that they had a successful plane that had flown twenty-four miles at a speed of thirty-eight miles an hour. The public was astounded to think they had accomplished so much without attracting attention. Many refused to believe in them.

The Wright brothers, in order to protect their rights, took their machine to pieces and put it away until they were given an offer for their patents. Two years later the government of the United States asked for bids on a "heavier-than-air" machine. The Wrights offered to demonstrate their invention and to sell the rights for twenty-five thousand dollars. A test was made, and their offer was accepted.

In May, 1908, the first public test was made when Wilbur Wright flew eight miles and landed safely. In the same year ten flights were made in the new government ships, the longest one being a mile and a half.

In 1909, a second endurance test was made with President Taft present and a great crowd watching. Orville Wright took the wheel while Wilbur whirled the propeller and started the motor. The Signal

Corps men raised the weight and fastened the end of the starting rope to the plane. There was one passenger in the car.

The plane mounted in the air. It circled round and round while the great crowd stood amazed below. After the machine had been in the air an hour, there

Aviators Over San Diego, California, Celebrating Peace

were wild cheers. Orville Wright kept the plane in the air a trifle over twelve minutes more and then came safely to the ground.

President Taft hastened to shake him by the hand. "Good work!" he said. "It was a wonderful performance! You have beaten your brother's record, which was one hour and nine minutes."

"Oh, that does not matter," said Orville, quietly; "it is all in the family."

This modest manner of taking success was very like the Wright brothers. They refused to show off at any time, or to take any risks that were not necessary. Several times they disappointed large crowds that had gathered to see a flight because they thought the weather was unfavorable. They had worked out a machine which was of untold value to the world, but they were not seeking applause for reckless experiments. It was left to more daring aviators to attempt dangerous feats and show the real possibilities and value of the Wright machine.

When the Wrights went to Europe they were given many honors, especially in Germany where Count Zeppelin had invented the dirigible balloon. Everywhere they received much attention.

During the World War the airplane developed very rapidly. The airmen were most effective scouts. They photographed places behind the enemy's lines and dropped many bombs. There were battles in the air when both the Germans and the Allies sent their enemy's planes crashing to earth. The machines made for war service had powerful engines and wings for high and fast climbing. The war, as we know, developed the Liberty motor.

When the war was over, attention was turned to making commercial planes at less cost. Airplanes were soon used for transporting mail, and presently thirty million letters a year were carried by air service.

The first non-stop flight across the United States was made from New York to San Diego in 1923. It was accomplished in a little less than twenty-seven hours, at an average speed of about a hundred miles an hour. Airplanes had already crossed the Atlantic

Kadel & Herbert

Coast-to-coast Fliers Lieuts. MacReady and Kelley Starting on the Non-stop Transcontinental Flight

by landing at islands on the way.

Lieutenant Lowell H. Smith and five other brave airmen of the American navy set out from Seattle in April, 1924, to fly around the world. Five months later they landed in Labrador and a little afterward arrived at their starting point, victorious. Our navy heroes met with many hardships and dangers, more perhaps than did

Magellan in his tiny ship four hundred years before. They came upon dreadful fogs and blizzards in the Pacific; they ran into typhoons off Japan, into monsoons in the Bay of Bengal, and sand storms across India and Persia. Then there were icebergs and fogs in the Atlantic to test our heroes. They had accidents, too, with their

Kadel & Herbert

Lieut. Maughn, the Dawn-to-dusk Flyer

airplanes, but they kept their courage and boldly conquered.

Then in May, 1926, another daring American navy flyer, Lieutenant Richard E. Byrd, and his pilot, Floyd Bennett, made a non-stop flight from Spitzbergen, Norway, to the north pole and back — a distance of 1600 miles. As they sailed over the top of the world, they

dropped the stars and stripes at the pole. This was but a few days before the dirigible *Norge* also sailed over the pole.

At an exhibition in New York that year, an eight-passenger, limousine airplane with a closed-in cabin with wicker chairs and toilet room was shown. This airplane had carried many passengers between Pittsburgh, Philadelphia, New York, and Washington.

There were also exhibited small planes which could successfully alight in a city street. These planes cost about two thousand dollars, and the air men announced that when they could have a parking or landing field every ten miles they were ready for service.

Since the airplane can travel twice as fast as an express train, it promises to play a great part in rapid transit. A trip to Europe may be a week-end pleasure, and family planes will soon be as common as automobiles. Air routes will be established all over the world in a few years.

Questions and Problems

1 What is the chief difference between an airplane and an airship? Which is safer? Speedier?
2 What has made the navigation of air so much more difficult than that of water?
3 What other inventions and discoveries did the airplane have to wait for?
4 What was the first problem the Wright brothers solved?
5 How was the airplane used in the war?
6 What difficulties are there in flying at great heights?
7 In August, 1924, Phillips flew from Texas to Ohio in an airplane with a wing spread of 18 feet. Why was that interesting? Measure 18 feet on the floor.
8 Tell of the airplane flight around the world.

CHAPTER XVI

THE STORY OF AIRSHIPS

WHEN our Civil War broke out in 1861, no one dreamed of flying and fighting in the air. But Thaddeus Lowe said that he believed captive balloons which were held by a rope from the ground could be used to watch the enemy. He thought that by connecting the balloons to the ground by telegraph wires the balloonist might even direct the artillery fire. The war leaders did not like the idea of using such a frail thing as a balloon in the rough affairs of war.

So when Lowe's offer was refused he went to President Lincoln with his plan. He made an ascent in his balloon while the President looked on. In order to test him Mr. Lincoln took off his hat, waved his handkerchief, and made other signals. Lowe observed them through his field glasses and reported them to the President by telegraph. Mr. Lincoln was much impressed and ordered the army to use the observation balloon, which played an important part in the work of the Union Army during the war.

A young German, Count Zeppelin, who came to observe the army tactics at this time, begged for the privilege of making an ascent in the balloon. It was granted. When he returned to earth, he was wildly enthusiastic. He had had a fine view of the enemy through field glasses and saw the great possibilities

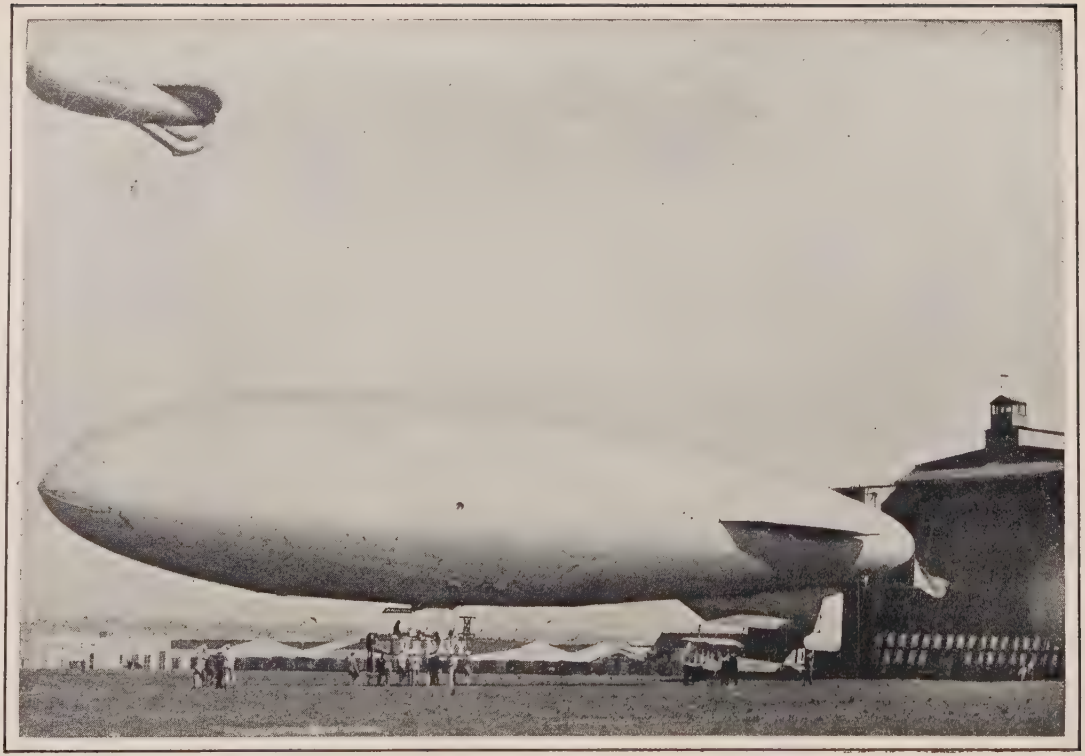
of the use of the balloon in war. When he returned to Germany, he urged the military leaders there to adopt the captive balloon for war use.

The first balloons were filled with hot air which is lighter than cold air because it has expanded. An

A Dirigible at Anchor

air-filled balloon will come down as soon as the air in it cools. But since hydrogen is the lightest of all gases known, it soon came into use in balloons.

Hydrogen weighs only about one sixteenth as much as air. It, therefore, has very much greater lifting power than hot air, and will stay up as long as one wishes. But it is highly explosive, and so there is



U. S. Navy Official Photo, San Diego, California

TOP LEFT, KITE BALLOON; CENTER, BLIMP

always great danger of fire in its use. The reason that a gas-filled balloon rises and has lifting power is that the air outside the balloon, being heavier than the same volume of gas inside, crowds under the balloon and pushes it upward. Since hydrogen is lighter than air, a hydrogen-filled bag will float in air just as a piece of wood will float in water because it is lighter than the same volume of water.

As the balloon rises from the earth, the air becomes less and less dense or, in other words, it becomes lighter. The balloon will keep on rising until it reaches a point where the gas bag and its contents weigh exactly the same as an equal volume of air surrounding it.

When the sun beats on the balloon it heats the gas, causing it to expand and become lighter. Thus the bag will rise higher. If there is no room for the expansion of the gas, it will burst the bag. For this reason a round balloon is always left open at the bottom so the gas can escape and save the bag from bursting when the sun shines. When the balloon is used in cloudy or misty weather, the bag is cooled and becomes heavier and will not fly so high.

Since a balloon carries no engine to drive it along, it has to depend on the air currents to carry it. The balloonist can guide his course somewhat. He may send the balloon higher by throwing over some ballast, or he can descend by letting out some gas by means of a valve in the top of the balloon, which he controls by a cord. Thus he may go up or down till he finds an air current or breeze blowing in the direction he

wishes to go. The free balloon was not used in the Civil War, only the captive balloon held by a rope to the ground.

Count Zeppelin wanted to build a real airship that could be controlled and sailed wherever the helmsman chose, regardless of the wind. He attempted to make big machines which were very expensive. Naturally his first ships were crude and came to grief. Every time he lost an airship he set out to build

Playing Tag with the Clouds

another till he was heavily in debt. Every one thought him a crank until he succeeded in building one that made a trip of two hundred and seventy miles. Then the German government became interested in the new craft and its use in war, and Zeppelin was furnished money to continue his experiments.

Each Zeppelin was an improvement on the one before, but for a time misfortune wrecked them one

by one. Before the World War thirteen had been destroyed. Still the German government made up the losses, and the Count went on improving his airship. Other nations, especially France and England, also built dirigible ships, but they did not see much future for them after the airplane was invented, because it was a much faster craft.

As Count Zeppelin wished to drive his ships

Starting Out on a Flight

through the air, he wanted them to hold their shape, so he made them rigid. The framework was made of a mixture of aluminum, copper, and nickel, so as to be as light as possible and yet be very strong. It was covered over with canvas. The gas that gave it the lifting power was in many separate bags within the ship. The reason for this was that if one bag were punctured, the craft would still sail.

The later Zeppelins were more than seventy-five

feet in diameter and about eight hundred feet long, or as long as several city blocks. The machine with all its fuel and stores would weigh fifty tons or more. Yet the hydrogen gas was so much lighter than air that the ship had a lifting power of ten tons or more. It carried a crew of about twenty men.

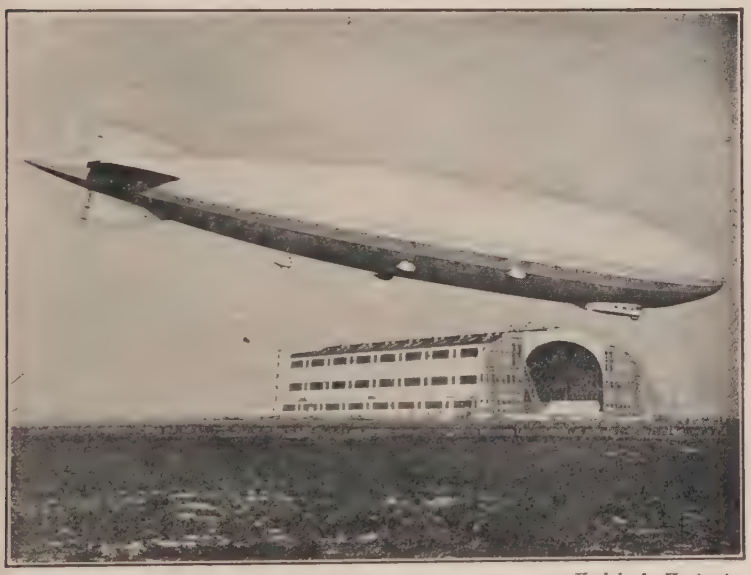
Since hydrogen is so explosive, it was extremely dangerous to have an engine operating near the gas bags, so the Zeppelin engines were placed in four cars suspended some distance below the balloon.

The war Zeppelin carried water as ballast to be thrown overboard when there was need for rising quickly. Because of the extreme cold in the upper air, alcohol was mixed with the water to prevent freezing. The Germans spared no pains to keep the Zeppelin secrets from their enemies; but on one occasion when an airship was returning from a bombing raid, the water ballast froze, and because of this the Zeppelin was forced to land in France. Before the ship could be destroyed by its crew, it was captured by the French and all its secrets became known.

Because of fear of airplane attacks the Zeppelins raided enemy country only at night, but in the latter part of the war searchlights at the landing fields enabled airplanes also to fly at night. In darkness it was difficult to locate a Zeppelin, because the ship could not be seen and the throb of its engine was drowned out by the engine of the airplane itself.

Whenever the swift little airplanes could locate a Zeppelin the big airship was quickly destroyed, because it was easy to set fire to the very inflammable

hydrogen gas that filled the airship. The airplanes carried machine guns with explosive bullets for this purpose. The airplanes could fly twice as fast as a Zeppelin, and they avoided the shrapnel from the airship by flying above the big balloon. Then the

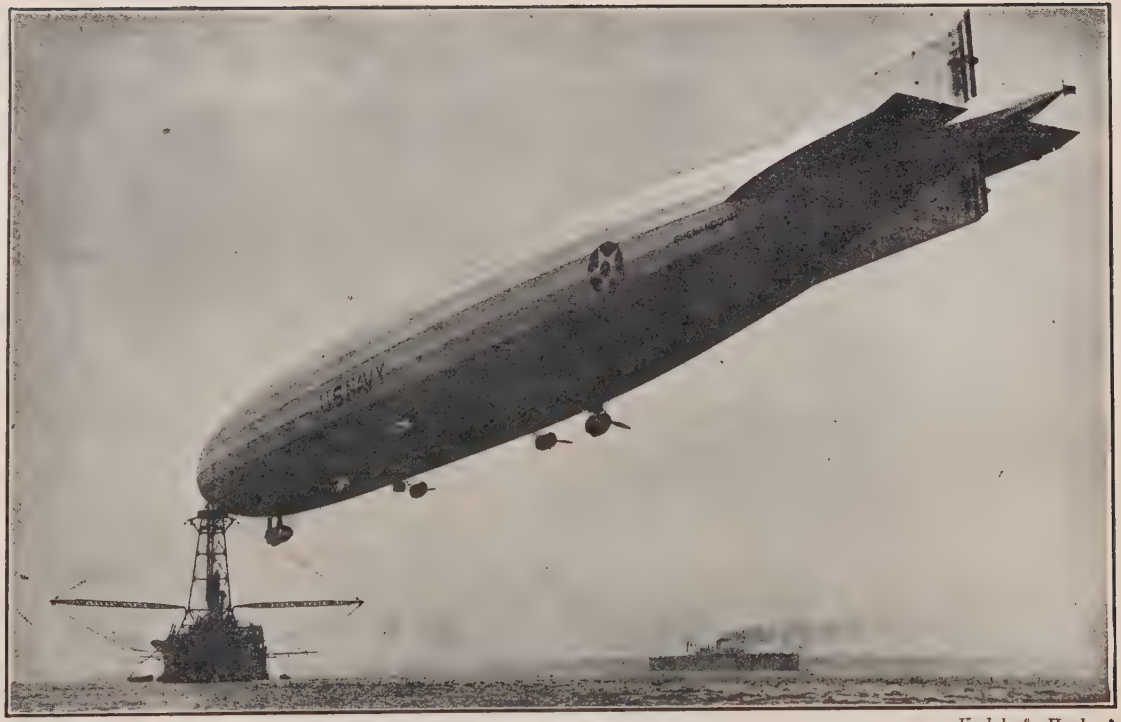


—*Kadel & Herbert*

THE *Los Angeles*—FORMERLY THE GERMAN *ZR3*

Zeppelins were provided with guns on top of the balloon. Still the airplanes swarmed about the big ship and destroyed it. Thus the Zeppelin proved a failure in war, because it was so costly to build and so easily destroyed.

When the United States entered the war against Germany, our allies asked us if we could not find a substitute for hydrogen gas that would not burn or



—*Kadel & Herbert*

THE *Shenandoah*, MOORED TO THE MAST OF THE S.S. *Patoka*

explode. They told us helium gas would do if we could get enough of it and make it cheaply. Helium gas was discovered by the spectroscope in the flaming atmosphere of the sun in 1868. It was not until 1895, however, that it was known to exist on the earth. It was a marvel that it was discovered ninety million miles away before our chemists could find it here. But when they found helium here, it proved the lightest of gases and it would not burn. But neither would it combine with any other elements, and so apparently it had no use on earth. Therefore, very little of it had been produced.

When we saw its fitness for the airship, there was only a small amount of helium in the whole world. Not a single laboratory in America had more than five cubic feet of it, and its price ranged up to six thousand dollars per cubic foot. At this rate it would cost upward of three billion dollars to make enough helium gas for one airship of the Zeppelin size.

Fortunately, about this time helium gas was found in the natural gas of Oklahoma, Texas, and Kansas. The problem now was how to separate it. Now all other gases can be reduced to a liquid if they are cooled sufficiently, and further cold will freeze them solid. But helium is very hard to liquefy. It must be reduced to 450 degrees below zero before it becomes a liquid.

From this fact a chemist hit upon the solution of separating helium from the other gases by cooling the mixture gradually. Since helium can stand more cold than any other gas, this was tried, and one after

another as the temperature was reduced, the other gases became liquids until finally only helium was left. Thus the problem was solved.

Travel by Air and Water

The next problem was to get helium in a large amount and do it cheaply. Helium could not be used in airships unless its cost per cubit foot could be re-

duced to ten cents. Our chemists finally succeeded in doing this, and by the end of the war helium was being produced at eight cents per cubic foot.

With helium gas the engines can be placed inside the balloon envelope and the propellers can operate on the center line of the ship, which greatly increases the speed. Thus the United States furnished the one

—*Kadel & Herbert*

THE *Shenandoah* ENTERING ITS HANGAR

element which was lacking to make the dirigible airship safe from explosion.

After the war a huge plant was built at Fort Worth to separate helium from the natural gas that was used by Fort Worth and Dallas. The plant could turn out as much as forty thousand cubic feet daily. The helium was compressed and stored in steel cylinders. Our government had on hand by 1924 over eighteen

million cubic feet, which was practically the entire world supply.

The navy dirigible, *Shenandoah,* filled with helium, made successful flights along our eastern coast and as far west as Seattle. Later in a flight over Ohio it was wrecked in a storm and its able commander was killed. In May, 1925, an Italian airship, the *Norge,* flew from Rome to Spitzbergen, Norway, and then sailed calmly on over the North Pole, keeping in touch with the world by radio most of the time. What the future use of the lighter-than-air vehicle shall be we hardly dare predict.

Questions and Problems

1 Who was Thaddeus Lowe?
2 What did Zeppelin learn in our Civil War?
3 How does hot air carry a balloon up?
4 Find out all you can about hydrogen gas.
5 How did hydrogen help the development of the airship?
6 How is a balloon controlled?
7 Why were the engines placed far below the gas bag in an airship?
8 Why were airships made rigid? Did they have one or many gas bags? Why?
9 Tell about the ballast of a Zeppelin.
10 Describe the advantages of airships and airplanes in war.
11 What is helium and why useful?

CHAPTER XVII

THE SUBMARINE

IT was during the War for Independence that the first submarine was used. David Bushnell built a tiny craft called the *Turtle,* because it resembled a turtle. The queer boat stood on end and carried a crew of one. It was operated by two oars worked from the inside by a crank, and could remain under water half an hour.

When the lonely captain and crew of this little boat wanted to submerge, he opened its ballast tank and let it fill with water. When he wished to come to the surface, he pumped the water out just as big submarines do to-day, but he did this by hand. The *Turtle* had a lead keel weighing two hundred pounds that kept it from turning over. If the captain wished to rise to the surface very quickly because of accident, he could cast this heavy keel loose.

The boat carried on deck two hollowed-out pieces of oak filled with gunpowder. Its plan of operation was to dive under a warship, bore a hole in the hull, deposit the crude torpedoes, and get out of range before the explosion.

The *Turtle* set out to sink the British warship *Eagle* as she lay at anchor with her guns trained on New York. But on coming up under the *Eagle,* her hull was found to be covered with copper and it was

International Harvester Co.

U.S.S. *Omaha* AND "S" TYPE SUBMARINE

impossible to bore into it. So the brave little *Turtle* was unsuccessful. Two other attempts to blow up British ships also failed. Then the little craft came to a sad end when a ship, carrying her, sank—submarine and all.

The next inventor who tried his hand on submarines was Robert Fulton, and the story of his failure you have already read in the chapter on the steamboat.

In the Civil War the first successful attack was made by an under-sea boat. A little submarine called the *Hundley* was built by the Southern Confederacy. It moved along just under the surface, being able to dive for only a few minutes at a time. One night in February, 1864, this little craft carrying a crew of nine and a crude torpedo entered Charlestown harbor and steered straight for a Union warship named the *Housatonic.* Its torpedo struck the big ship near the magazine, and the terrific explosion sank her in a few minutes. But the submarine and its crew were also lost, for they were too near when the ship was blown up. The victim and victor lay side by side at the bottom of the sea.

After the Civil War nothing more was done to improve the submarine for many years, because there were great difficulties in the way. One obstacle to overcome was that there was no way of propelling the boat while under water. Steam could not be used because it requires so much heavy fuel and air for the fire, and enough air could not be carried in the submarine.

At last there came three important inventions that

were of great use to the under-sea craft. One was the gasoline engine which is light and which uses fuel that does not take much space. This engine can be used to drive the boat when it is on the surface. Then the electric motor and the storage battery which could be charged with electricity could be used under water to propel the boat. Electric power does not require air or oxygen to operate.

Simon Lake thought of the many wrecked ships and rich cargoes lying under shallow water on the ocean bottom and concluded he would build a submarine boat to salvage these vast treasures. In 1894, therefore, he built the *Argonaut Junior,* a very small craft only fourteen feet long. It was equipped with wheels for moving along on the ocean bed. Through a compartment in the bow a diver was able to step outside for salvage work. The boat could go no deeper than twenty feet, but yet was very successful.

Mr. Lake then built two larger boats equipped with gasoline engines. They carried sleeping quarters for the crew and an air supply to last forty-eight hours. These vessels submerged by admitting water into ballast tanks and rose again by pumping it out and putting air in its place. They used the gasoline engine for traveling on the surface and the electric motor and the storage battery under water. The Lake submarines could weather the roughest sea, and their speed was 8.5 knots on the surface. Since the United States was unwilling to buy them, one was sold to Russia and brought to Vladivostok.

The real inventor of the modern submarine was

John P. Holland, who was born in Ireland in the year 1842. When a young man he came to America where he built seven submarines, none of which was very successful. But in 1898 he launched the *Holland No. 8*, a successful boat moving about under water like a fish.

U. S. Navy Official Photo, San Diego, California

SUBMARINE AND N9 TYPE SEAPLANE

On the surface it had a speed of eight miles an hour and could sail fifteen hundred miles without taking on more fuel.

Men began to see that the day of the fighting submarine had come. Holland sold plans for these undersea boats to the United States, England, Japan, and

Germany. Submarines were rapidly improved and came to be built much larger. Holland never lived to see the result of his invention in war. A fortnight before Germany declared war in 1914 Holland died. He believed that submarines would destroy all enemy warships most speedily. In this he was mistaken.

It was found extremely dangerous to use gasoline

Speedy Submarine Destroyers

for power under the surface, because it is impossible to prevent it from evaporating and escaping into the air in the boat. Then a spark from an electric motor may fire it and destroy the craft. Then, too, gasoline requires a high-speed engine which uses much fuel, and as it has to take on fuel often it cannot cruise far from its base.

All these difficulties were overcome when the Germans invented the *Diesel* oil engine. This is a low-speed engine which uses heavier and cheaper oils, such

as kerosene and benzol, and fires its charge without an electric spark. The cylinder fills with air and the upstroke of the piston compresses the air into very small space until the pressure is five hundred pounds per square inch. This extremely high pressure executed so quickly makes the air so hot that when the oil is sprayed into it the explosion takes place without an electric spark. The Diesel engine gives greater power on less fuel, and there is no danger from explosion of escaping gasoline. Since the war it has come to be used on all under-sea craft, and is one of the greatest inventions of recent times.

Questions and Problems

1 Describe Bushnell's *Turtle*. Why did it fail?
2 What was the fate of the *Hundley?* Why?
3 Tell about Simon Lake's submarine.
4 Why is Holland considered the real inventor of the submarine?
5 Describe the Diesel engine. Why is it a great invention?
6 What were some of the problems to be solved in building a successful submarine?

CHAPTER XVIII

THE SUBMARINE IN THE WAR

SINCE Germany could hardly hope to battle against England's fleet on the open sea, she put much care and study on the submarine. When the Great War broke out, the German submarine or U-boat was less than 150 feet long with a speed of 12 knots an hour. But as the war wore on, these boats were built larger and larger until they reached 300 feet in length with a speed of 18 knots an hour.

The U-boats were built to navigate mostly on the surface, but they were also made to withstand the crushing weight of deep water. As a cylinder can bear greater pressure than any other form, the main hull of the submarine was cigar shaped. But a boat of this shape will not keep its balance well among waves on the surface, and so the cigar-shaped hull was built into the form of a surface vessel so it would not upset so easily. The space between the inner and outer hulls was used for water ballast and for oil to drive the engines. A heavy lead keel was made fast to the bottom of the boat to keep it from rolling too much. In case of accident this keel could be cast loose.

A submarine under water must keep its propellers going to avoid either sinking to the bottom of the

U. S. Navy Official Photo, San Diego, California

A Mother Ship and Her Brood of Undersea Fighters

sea or bobbing up to the surface. If it should sink to a depth of more than three hundred feet, the weight of ocean water would crush the hull. So it is a case of sink or swim.

For surface movements the Germans used the great Diesel engine, and under water where no air is to be had for the engine they used the electric motor. When the batteries were low, the U-boats had to come to the surface to recharge. This was done by running its engines several hours. The German U-boats did not average over three hours a day under water.

The later U-boats carried crews up to forty men, and they preferred slender men to stout ones. It was very cold living on submarines in winter and the men had to pile on much clothing to keep warm, especially when under the icy water. This made even slender men very bulky. The hatchway was so small that a fat man bundled up could hardly squeeze through.

In the conning tower was room for the captain and three or four other men. Here were the compasses and the periscopes or eyes of the boat. There were usually two periscopes rising from fifteen to twenty feet above the conning tower. Through these the man at the wheel could see ships on the surface of the water when he was safe many feet below.

When the submarine's periscope does not reach the surface, the boat is absolutely blind. The captain cannot even see the bow of his own boat. He goes about feeling his way with compass and depth gauge, so he will not run ashore or into the shallow bottom of the coast.

It was an anxious moment while the submarine was coming up until its periscope broke out of the water and the captain could get his bearings. He might collide with a ship on the surface, or his periscope might be quickly seen because it leaves a wake as it moves along. The boat always ran a chance of being destroyed before it could dive again to a safe depth.

The Germans later invented a periscope that could be raised and lowered by means of a hand lever. The U-boat would run along just under the surface, and every now and then the captain would poke up his periscope for a few minutes, then drop it again under cover if there was any danger near.

In the bow of the boat were the torpedo tubes from two to four of which were kept loaded ready to fire rapidly if needed. On the end of each tube was a cap to keep out the water when a fresh torpedo was to be put in. When ready to fire the cap was opened and the torpedo sent forth into the water by a blast of air.

The torpedo is shaped like a cigar from fifteen to twenty feet long. It is really a motor boat fitted with its own engine and driven by compressed air. It travels about fifteen feet under water to avoid being turned by waves, and it goes about forty miles an hour. The air motor starts just as the torpedo is blown out of the tube and it drives two propellers. The front end of the torpedo is packed with four hundred pounds of TNT which will explode when it strikes.

Besides the torpedoes the later submarines carried guns sometimes six inches in bore, to be used when

U. S. Navy Official Photo, San Diego, California

DESTROYERS AT THEIR REPAIR BASE

on the surface of the water, as torpedoes are very costly. The guns were at first built to disappear, but later they were made fast on deck and well greased to keep them from rusting.

The submarines kept in touch with their base by radio when many miles at sea. The radio was used mostly at night when the U-boat was on the surface. The masts for radio work could be folded down into pockets in the deck. The later boats also had keen-toothed knives at the bow which would cut through a steel net.

The British also did splendid work in improving their submarines during the war. It is said they excelled the Germans in this respect. The British built a great submarine 340 feet long driven by steam with a speed of 24 knots on the surface. It was more than three times as large as any built by the Germans. Its smokestacks folded down when it submerged. When under water it ran on electric power like the others.

More remarkable yet was the big "super submarine" built by the British to bombard forts. It carried a 12-inch gun, which was as big as most of the guns on battleships.

A U-boat could remain under water for two whole days lying on the shallow bottom. There was plenty of air in the hull to sustain the men, and if kept under longer they could use the compressed air that was intended for blowing the water out of the tanks. In the U-boat were potash tablets to keep the air pure by taking up the carbon dioxide which was breathed out

by the men. Tanks of pure oxygen were carried to tone up the air again.

A diver was fitted out with oxygen and potash tablets for his helmet so that he could be let out of the U-boat through air locks to make repairs under water. Thus he did not need to be connected with the boat by air hose, but he could walk around the U-boat lying on the bottom of the sea to mend injured rudders or to clear the propellers of entanglements.

In the beginning of the war the captain of the U-boat had an easy time of it. His prey was always on the surface and he could remain safe under water, using his torpedoes as he pleased. But in the war the U-boats were hunted down until the crews lost their courage.

The great enemy of the U-boat was the tiny submarine chaser, or the swift destroyer. It was useless for the U-boat to discharge a torpedo at so small and speedy a foe. Besides, the torpedo has to keep fifteen feet below the surface to avoid being turned by the waves on the surface, and this was too deep to reach the hull of the chasers. The U-boat captain dared not come up and use his guns, for the surface ships would have destroyed him before he got ready to fire. Besides, he dared not expose his precious inner hull to gunfire. When destroyers were around, he dared not show even his periscope above water, for they at once gave chase and dropped bombs on him that would spring the seams of his U-boat even if they did not make a direct hit.

The British trained sea gulls to hunt submarines.

These birds will follow a ship far out to sea to feed on the refuse that is thrown overboard. From the air a bird or an airplane driver can see down fifty feet into the ocean and spot a submarine. So the British submarines coaxed the gulls along by throwing out bait or food whenever they came to the surface. In this way the birds learned to follow submarines as far down as they could see them from the air. Often the German U-boat was followed by these telltale gulls and was thus located by the British.

English sailors also trained sea lions in the same way to follow submarines by giving them fish. The sea lions pointed out the U-boats by swimming after them and diving down in their wake.

But it was the seaplanes and blimps that sailed over the coast waters that proved the best spotters of U-boats. They could see submarines to a depth of from fifty to seventy feet below the surface unless the sea were choppy. When they discovered one, they at once signaled to chasers to destroy the U-boat with bombs. Thus the German U-boats were driven farther out to sea for safety.

The merchant ships learned how to avoid the submarines by camouflage and by going zigzag instead of in a straight course. This kept the U-boats guessing, for they always had to aim the torpedo ahead of the moving ship.

Then the merchant ships found a way of hiding on the surface by spouting forth dense black smoke and dodging behind this heavy smoke screen. Smoke boxes containing a mixture of tar and other chemicals

U. S. Navy Official Photo, San Diego, California

A Modern U.S. Destroyer

were also cast overboard to form a screen of black smoke behind the vessel.

The U-boat captain found sometimes when he raised his periscope above the water that he could not see because the glass was smeared with a sticky, tar oil that the ships had spread over the waters for many miles. This blinded him at first, but he later provided a jet of water for washing off the periscope glass.

Then there were the dreaded shells that the destroyer sent after the U-boats. Shells had been invented that would not glance off when they struck the water, but would plow straight down and hit the submarine below the water level.

Still worse for the U-boats was the depth bomb, called an "ashcan" and loaded with TNT. These bombs were timed to explode far under water so as to crush a submarine or start its seams to leaking, if they exploded within a hundred feet of it. The bombs were rolled off the stern of the destroyers or thrown out from the sides as the ships wheeled and circled over the enemy.

The depth bombs shook the nerves of the U-boat crew. On one occasion a German submarine had been bombed and its electric lights put out of order, leaving the crew in utter darkness. They lost their nerve, overpowered their officers, and brought the U-boat to the surface. The hatch flew open, and the crew rushed out holding out their hands in surrender. The submarine was uninjured except for its lights.

Inventors all over the world were at work on "ears"

or a sound detector that could aid in locating U-boats. The best invention of this kind came from a group of American inventors, and is called a hydrophone. It can detect a submarine engine miles away and make out its direction. As the destroyers moved about, the sound grew fainter or louder according to the distance from the U-boat. By this means the Allied destroyers set out to hunt the U-boats. They could really follow them about by using this hydrophone and destroy them by dropping bombs. Two surface ships working together with hydrophones could locate a submarine accurately, and many U-boats were chased to their doom in this manner.

Questions and Problems

1 Give reasons for the shape of the submarine boat.
2 Why an inner and an outer hull?
3 Of what use was the lead keel?
4 A submarine must either sink or swim. Explain.
5 Explain the periscope. Can you demonstrate its construction?
6 How does the captain know his location when under water?
7 Why is it an anxious moment when he reaches the surface?
8 Describe a torpedo and its use.
9 What is **T N T**?
10 What did the British achieve in submarine building during the war?
11 What is compressed air?
12 Explain the use of the depth bomb in the war.
13 What is the hydroplane? How used?

CHAPTER XIX

OTTMAR MERGENTHALER AND THE LINOTYPE

JOHN GUTENBERG invented the printing press and devised type to be set by hand. For many, many years after that the compositor who set the type for the printed page used his method. Before him were one hundred and fifty compartments. In his left hand was a "stick," or metal receiver for the type. In an hour a practiced compositor could set about three hundred and fifty words. After his columns were printed he had to distribute his type, returning each letter to its proper compartment by hand, which took a third as much time as setting it in the first place.

To-day the operator sits before a Mergenthaler linotype instrument, which is a machine for setting type. By its use one printer can now do the work of about eight in setting type by hand. He has a keyboard of ninety characters, something like a huge typewriter, and a form for each letter and sign called a matrix. By pressing the keys he moves the matrices or forms of the letters into a line of words ready for printing. When the operator has set all the words the line will hold, the molds are filled with melted type metal and a solid line of type is cast. This line of words is called a "slug."

As fast as a slug is made it passes to a tray until

other slugs are added, and the whole page of the paper is set up and cast. The machine then returns the matrices to their proper places. They all pass together through a slide, and then each one passes through a little tube which is designed to fit that particular matrix. After the "slugs" have been used in printing they are melted, and the lead is ready for use again.

We can readily see that a man who made anything so fine and delicate as the matrices for type must have been a fine workman. Gutenberg, the printer, was a cutter of gems, was accustomed to doing fine work, and Mergenthaler, the inventor of the linotype, was a watchmaker who was also used to the most delicate and accurate tools.

Ottmar Mergenthaler was born in Germany in 1854. His parents were teachers. Ottmar received his education in his father's school. He worked very hard at home helping to cook and wash dishes and care for the stock. Often in Germany a young man follows in the footsteps of his father, but Ottmar did not wish to teach. He was instead apprenticed to a watchmaker, and gave four years to perfecting his trade. He did so well with his work that the man paid him thirty dollars for the last year of his service. This was a real honor, as apprentices worked for nothing. Ottmar had also studied mechanical drawing at night, which was of use to him later.

To escape German service in the army, Mergenthaler decided to come to America. He landed in Washington, D.C., with his thirty dollars, and was

fortunate enough to secure a government position. Here he came in touch with many inventors. Among the inventions he examined were several writing machines. He made successful improvements on some of these.

This experience led Mergenthaler to believe that he could invent a linotype machine. For several years he worked, using papier-mâché for his type, but it would not dry fast enough. Then he substituted fluid type metal which hardened readily. One day he was making a trip on a train to consult with friends about his invention when suddenly a new idea flashed into his mind:

"Why not stamp matrices on type bars and cast the fluid metal in them in one and the same machine?" From this thought he worked out the slug, which idea made the successful linotype machine.

Let us watch a machine at work. When the operator presses the key which corresponds to the letter, a brass mold or matrix which has the letter *a* impressed on its edge is released and travels down an inclined tube to a moving belt by which it is carried to its proper place in the line; then the letter *r* follows it—next the letter *t*, making the word *art*. The spaces between the words are formed by duplex wedges dropped into place in the same manner by pressing a key. When the operator has set the matrices of all the characters the line will hold, the machine carries it to the casting apparatus.

Here the line is properly spaced. The molds are then filled with melted type metal, and a solid line of

type is cast which the machine carries to its proper position in the stick. Then the operator presses a lever and the matrices are returned to the case. Each matrix has certain elevations or depressions on the back that guide it into its proper compartment. The operator is able to set about a page and a half of a large book in an hour.

Mergenthaler worked many years on his linotype machine. In 1884, a day was appointed when a few friends were to see it at work. Ottmar stood before his keyboard and composed a line on the keys, and the matrices slid into their places. He turned the driving pulley by hand and composed a second line. Removing the stopper from the metal pump, he touched the line key and the pump poured forth its hot fluid metal. A finished, shining linotype dropped from the machine, and each matrix took its way through the distributing machine back to its own compartment—all in fifteen seconds.

Then Mergenthaler invited a young woman who was an expert with the typewriter to sit at his machine. She had never seen the machine before, but she readily made a linotype. After twenty long years of toil he had won success.

The work of the linotype machine is so much faster than setting type by hand that it has had a tremendous influence in the world by making books cheaper and newspapers and magazines larger and more common. Much printing has encouraged learning, and many more people have obtained the foundations of an education.

Questions and Problems

1 What is a linotype machine?
2 What is a slug?
3 What is a matrix?
4 Go into a printing shop and watch the linotype work.
5 Explain why the linotype machine is a great invention.
6 Compare its importance with that of the typewriter.

CHAPTER XX

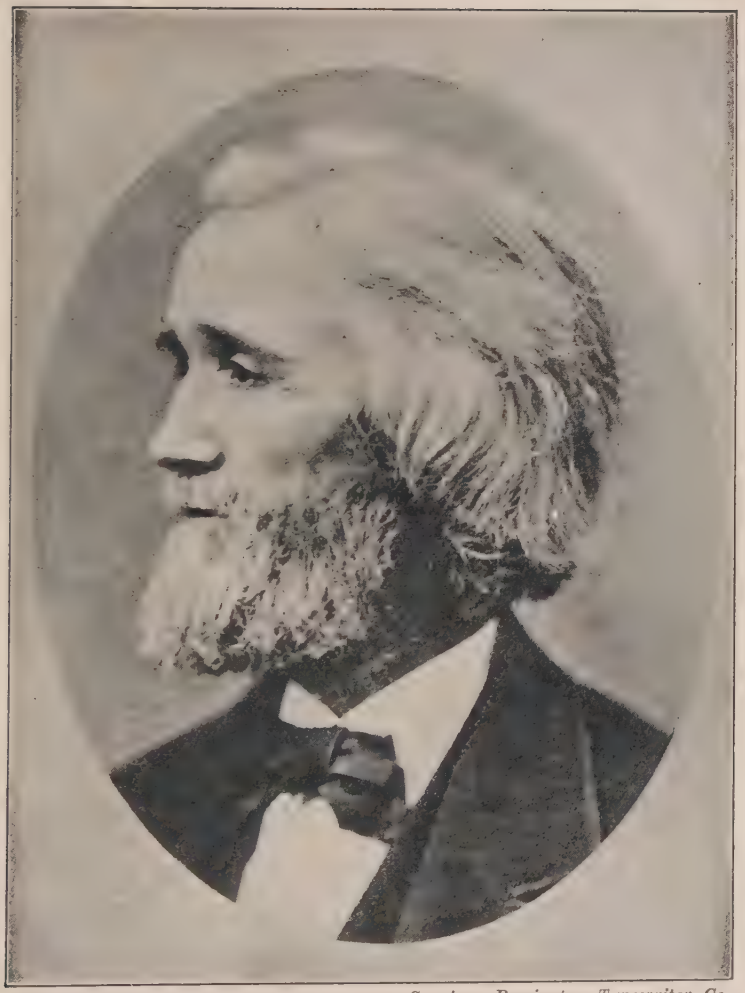
CHRISTOPHER SHOLES AND THE TYPEWRITER

AFTER printing came into general use stamps and name plates were used, but the work of numbering or lettering pages with stamps was very slow. It was about 1866 that men began to work upon the ideas that produced the typewriter.

Christopher Latham Sholes was born in Pennsylvania on Valentine's Day, 1819. He was a descendant of John Alden. At fourteen he was working in a newspaper office. At eighteen he was an efficient printer, knowing all about presses and the details of printing. In time he was in charge of a large newspaper in Milwaukee, Wisconsin. Along with his newspaper he did job printing. One day his printers struck, and in disgust he declared he would work out a machine that would do their work.

In his print shop Sholes manufactured many blank books, the pages of which were all numbered by metal hand stamps. He and a friend, Samuel Soule, began to work upon a machine that would do this numbering. They patented this numbering machine in 1866. When they showed it to their friends, they said, "Why not build a machine that will print letters and words as well as figures?"

The idea played in Sholes's mind. A year later he read an account of a writing machine, made by an



Courtesy Remington Typewriter Co.

CHRISTOPHER SHOLES

American, which had been shown in London. The account predicted that not many years in the future the only writing done with a pen would be a person's own signature. The rest would be compactly and neatly and clearly done on this new "literary piano."

Sholes thought from the description that this machine was too complicated and likely to get out of order. He and Soule went to work to make a simpler one. In the first model they built there was a keyboard like that of a piano with two rows of keys. The first row was of ivory, the second of ebony. The writing could not be seen until the page was removed from the machine.

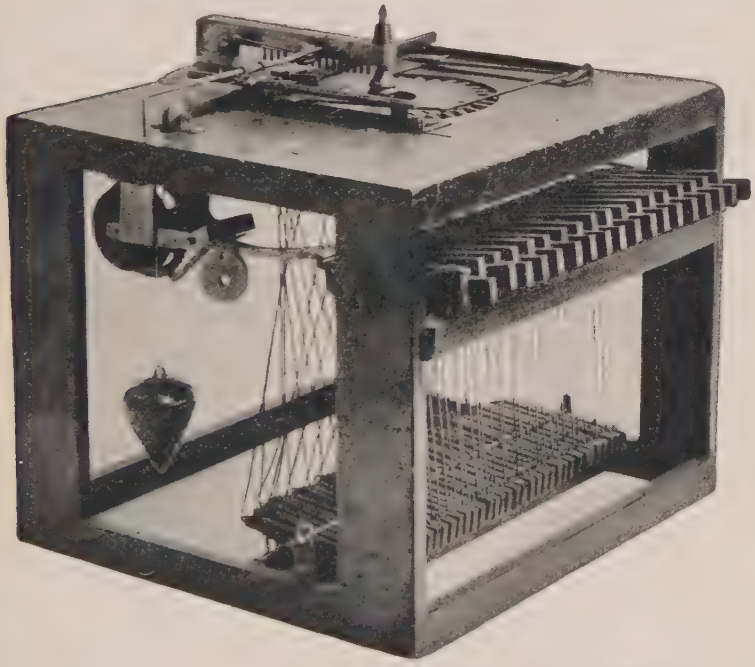
The two men took in a third friend named Glidden, and the three worked together in part of the shop. When they were tired, they played chess for recreation.

They patented their first typewriter in 1868. It had a circular disc and type bars to correspond with the disc. There was a ratchet to move the paper carriage by the breadth of a tooth when a key was struck. A hinged clamp held the paper. The first model was built on an old kitchen table and the letters were all capitals.

One morning they typed in capitals line after line clearly and successfully. It was an easy matter to advertise their new machine. They wrote hundreds of letters to their friends on their new typewriter and sent them out.

A man named James Densmore of Meadville, Pennsylvania, believed that the writing machine

would supplant the pen. He was so impressed with the machine that he asked for an interest in the venture. For a fourth interest he was willing to pay all the expenses of manufacture to date. But having



Courtesy Remington Typewriter Co.

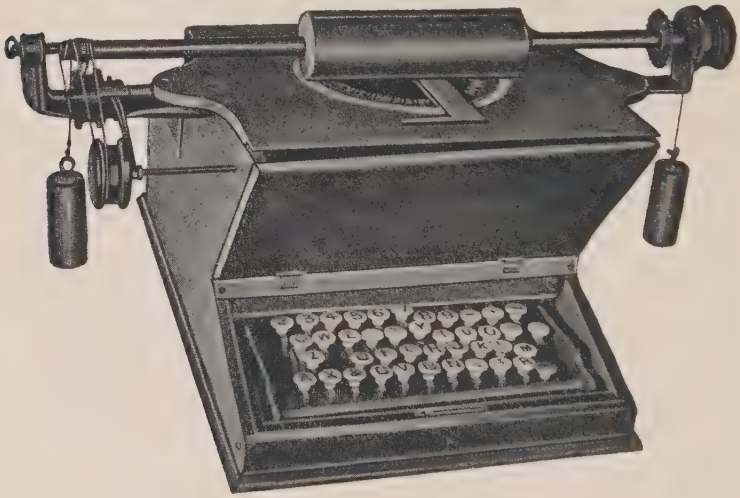
TYPEWRITER PATENTED JULY, 1868

secured this, Densmore insisted on many improvements. They built thirty or more different machines in an effort to improve it to the finest detail. They succeeded in increasing the speed and lessening the friction. Over and over Densmore had the models tested, first by one man and then by another.

"I am sick of all this fault finding," said Sholes.

"Let us find all the weaknesses before we begin to manufacture them," said Densmore.

At last the machine was ready and the inventors selected Remington and Sons of Ilion, New York, who manufactured sewing machines and tools, to build the



Courtesy Remington Typewriter Co.

TYPEWRITER PATENTED 1893

first typewriters. These people were used to making complicated machinery and had many experts in their employ. The Remingtons took hold of the enterprise with great enthusiasm. They not only built the first typewriters but bought the patent from Sholes and Densmore. They called the new typewriter the "Remington."

Sholes accepted twelve thousand dollars for his share of the patent, while Densmore took a royalty

Courtesy Remington Typewriter Co.

FIRST COMMERCIAL TYPEWRITER

which in time amounted to a million and a half. But Sholes and his sons built other typewriters with improvements. The most important one was a model that displayed the writing. Since that time hundreds of typewriters have been built, many with new features. James H. Hammond brought in a very successful new model.

To-day there are about twenty kinds of machines which supply the vast demand of offices, homes, and schools. All have a few of the features that Sholes's original machine displayed. The hitting of the paper with types at due intervals; moving the paper a suitable space after each stroke; moving the paper lengthwise at the end of the line, and striking a bell at the end of the line.

We now have the electrical typewriter, the small portable that can be carried about, and best of all the soundless machine. There is also the Braille with the raised letters on the keys to be used by the blind.

Typing is now taught in the public schools in some of the courses. When the typewriter first appeared, the operators were clumsy and slow. They used only two or three fingers of the right hand. To-day we have the touch system teaching the use of all the fingers on both hands, while the thumb moves the space bar. Great speed in writing is also attained. In contests two hundred words a minute are written, but accuracy and neatness are of more importance than such speed.

The typewriter is so much a part of our modern business life that a business man seldom sends out a letter written with a pen. By means of the machine a

much larger volume of correspondence can be handled. Moreover, it makes neat records and reports. The typewriter has brought thousands of women into the business world and opened to them other occupations than stenography and clerking. In almost every field of business, the typewriter is indispensable.

Questions and Problems

1 In what way did Sholes's experience prepare him for the invention of the typewriter?
2 What was the numbering machine?
3 What was their first keyboard like?
4 Why was Remington & Sons a good firm to make typewriters?
5 What is meant by a royalty?
6 Compare the amount received by Sholes with that of Densmore.
7 What are some of the improvements that have been made on typewriters since the first invention?

CHAPTER XXI

THE STORY OF THE TELEGRAPH

WHEN the packet ship *Sully* sailed from Havre for New York on the first day of October, 1832, Samuel F. B. Morse was one of the passengers on board. Mr. Morse had spent three years in Europe studying the famous pictures in the art galleries, and painting pictures of his own. He was now returning to his home in New York. Morse was at that time forty-one years old, and was considered one of the foremost American artists. He planned, on his return to the United States, to paint a great historical picture, which he hoped would be far better than anything he had yet done.

In those days the voyage from Europe to America was a long one, and the passengers had a great deal of time to spend in visiting with one another. One day, Dr. Jackson, one of the passengers, described some very interesting experiments in electricity which he had seen performed in Paris. Many discoveries had recently been made in the field of electricity, and there was a widespread interest in the subject. The electromagnet was one of the recent inventions. Dr. Jackson had a small electromagnet with him, and he, of course, was asked many questions about the magnet and the way in which it worked. Morse became very much interested in the discussions, and recalled some

of the lectures which he had heard while in college concerning electricity and magnetism.

The length of the wire in the coils of Dr. Jackson's electromagnet led some one to ask if it took a long time for the electricity to flow through such a long wire. Dr. Jackson replied that experiments had shown that electricity passes almost instantly over any wire, no matter how long. Mr. Morse then said, "If the presence of electricity can be seen in any part of the circuit, I see no reason why signals may not be transmitted instantly by electricity."

The idea of using electricity to send messages quickly from one place to another appealed to Morse. The more he thought about it the more firmly he believed it to be possible. So he spent the rest of his time during the voyage planning an electric telegraph. He drew in his sketchbook many diagrams to show how he thought such a telegraph might be made.

By the time Morse landed in America, he had the plan for the telegraph fairly well worked out. As he left the boat, he said to the Captain, "Well, Captain, should you hear of the telegraph one of these days as the wonder of the world, remember the discovery was made on the good ship *Sully.*"

Morse's friends were much surprised to find him more interested in working out his new plan for a telegraph than he was in painting a great historical picture. However, he had no money for the necessary apparatus, and for two or three years he had to spend most of his time in painting to make a living, and could work upon his invention only during his spare

hours. His brothers offered him a room in a business building in New York to serve as a shop in which he might work upon his invention. This room Morse used for a long time as a studio, workshop, kitchen, and bedroom.

It is hard for us to realize to-day what a task it was for Morse to test out his plan. He could not buy the apparatus he needed, but had to contrive ways of making it by hand. At that time electromagnets were not for sale. Consequently, he had to get a small rod of iron from the blacksmith and tell him how to bend it into horseshoe shape. Then this iron core had to be wound with insulated copper wire. Insulated copper wire was not to be had either. Even bare copper could be bought only in small quantities, and at a very high price. Morse bought a few yards of copper wire and wound it by hand with cotton thread for insulation. Other parts of the instrument were equally hard to get.

Morse wished, before he showed his invention to the public, to prove that it would be possible to send messages long distances with it. When the receiving station was a great distance from the sending station, Morse realized that the current might be so weak that the electromagnet would not have enough strength. To solve this problem he built a relay. The current from the battery at the sending station passed through the magnets of the relay, and there was no difficulty in receiving the message through the long, long wire. The relay is thought by some to be the most brilliant feature of Morse's telegraph.

Even after his decision to use a relay, his whole plan was not worked out. To make the telegraph a practical invention every station should be able to both send and receive messages. To demonstrate his whole plan, it was necessary to have at least two sets

Western Union Telegraph Co.

THE *Great Eastern*—THE SHIP THAT LAID THE FIRST TRANS-ATLANTIC CABLE IN 1865

of instruments. For two years Morse worked at improving his original instrument and starting a second one.

Finally, in 1837; five years after his voyage on the *Sully*, he asked some of his friends and acquaintances

into his studio to see his telegraph. All of them were convinced that it was really a practical device. Alfred Vail was one of those who saw the telegraph at this time. He was so impressed with the invention that he offered to supply the money and the materials necessary for carrying on the experiment further. Vail was a skillful mechanic. From that time on, he was a very great help to Morse in his work and became his partner.

With Vail's help, Morse succeeded in perfecting his instruments so that he was willing to show them to the public. He applied for a patent in this country, and went abroad to try to get patents in some of the foreign countries. At that time many different kinds of telegraphs were being invented, and a patent was difficult to get. The trip abroad was discouraging. It was not until 1840 that the United States government issued a patent to Mr. Morse.

By this time Morse had done all he could without government help. He wished Congress to appropriate money for constructing a telegraph line. He displayed the telegraph to Congress, and it was received in the main with enthusiasm. But some of our leaders ridiculed the idea. When the bill appropriating money for Morse to build a test line was brought before the president, the Postmaster General said that it would be foolish to throw so much money away. Morse's friends began to fear that the telegraph would never be a commercial success. Morse, however, did not give up hope that Congress would eventually give him the needed help.

Western Union Telegraph Co.

A Break During the Laying of the First Cable

February 23, 1843, was a momentous day in the history of the telegraph. It was the last day of the session of Congress. A bill, appropriating thirty thousand dollars for constructing a telegraph line from Washington to Baltimore, had passed the House of Representatives, but had not been voted upon in the Senate. At ten o'clock that night there were

many bills yet to be considered, and but two hours remained. Morse was told by one of the Senators that it was useless for him to stay; that his bill, even if brought up for a vote, would surely be defeated.

Greatly discouraged, Morse went to the hotel and prepared to return to New York next day. He had worked for ten years on the telegraph, and it was a bitter reward to have it turned down as an invention of no practical importance. Morse tells us that after buying his tickets to New York, he had only thirty-seven cents left.

But, happily, the last thing before adjourning, the Senate passed the bill. The next morning, to his great surprise, a young lady greeted Morse with the good news that the bill had passed at the last minute. His sadness turned to joy and, of course, he did not return to New York that day, but began immediately the work of constructing a test line between Washington and Baltimore. Mr. Vail was again of great help to him.

Unfortunately, Morse's first attempt was to put the wires underground. After spending half the money allowed him in laying the underground wires, the scheme had to be abandoned, and he decided to put the wires on poles, a much cheaper and more satisfactory plan. Glass insulators to prevent the electricity from flowing down the poles into the ground were provided.

The line was finally in working order, and the first message was dictated by the young woman who had brought Morse his good news. It was, "What hath

God wrought?" A battery of one hundred cells was used to furnish the current. The relays weighed one hundred and fifty pounds apiece and had to be adjusted very frequently. But improvements were rapidly made. Smaller magnets with finer wire were used in the relays. Fewer cells were used to furnish the current and better glass insulators were invented.

Western Union Telegraph Co.

SPLICING CABLE ON BOARD SHIP—ROME CABLE

An incident now brought the telegraph into the notice of the public. The National Convention to nominate a president was in session in Baltimore. Polk was nominated for President, and Silas Wright, who was in Washington at the time, was nominated for Vice President. Mr. Vail, in Baltimore, telegraphed the news to Morse in Washington. Morse

immediately told Mr. Wright of his nomination. Mr. Wright promptly asked Morse to telegraph to Baltimore that he declined the nomination. Morse did so and Vail reported this to the Convention, but the members refused to believe that a message could have been sent to Washington and an answer received in so short a time. A committee went to Washington to see Mr. Wright in person. It soon became known that the message had been correct. This won public faith in the telegraph.

On April 1, 1845, the line was opened for public use and regular operators were appointed. Vail was the operator at Washington. The charge decided upon was one cent for every four letters. The receipts for the first four days were one cent. A man who had nothing with him but a twenty-dollar bill and one cent wanted to see the telegraph work free of charge. This was against orders. He then asked for one cent's worth of telegraphy. At that time there was a code or list of signals by which messages could be sent more quickly than if each word were spelled out. In that code "4" stood for the question, "What time is it?" Vail sent the signal "4" to Baltimore. Baltimore answered, "1," which meant that it was one o'clock. Although this was only one half cent's worth of telegraphy, the man paid his cent and departed. This copper penny was the only revenue received for four days. On the fifth day, the amount taken in was twelve and one half cents. On the eighth day the receipts were one dollar and thirty-two cents.

Morse then offered to sell the telegraph to the

government for one hundred thousand dollars. Although people now admitted that the invention was immensely valuable, the government feared that the income would never equal the expense of keeping the lines in operation and refused to buy it.

Private companies were then formed which soon proved that a telegraph system could be operated at a profit. New lines were rapidly built, not only in this country, but also in Europe. Improvements were made in the instruments and in the methods of putting up the wires. Morse lived to see more than one hundred thousand miles of telegraph lines in operation in this country alone, and to know that the world recognized him as one of the greatest inventors of the time.

Questions and Problems

1 What was Morse's occupation in early life?
2 How came he to be interested in the telegraph?
3 What is an electromagnet? How made?
4 What were some of the difficulties Morse had to overcome?
5 Tell about Vail's aid.
6 Visit a telegraph office and observe how the instrument works.
7 Describe the Morse code.
8 What can you say of Morse's worries over Congress?
9 Do you think the government should have bought the invention for $100,000?
10 Do you know whether the governments of other countries own and operate telegraph lines?
11 Who owns and operates our post offices?
12 What can you find out about the Atlantic cable?

CHAPTER XXII

ALEXANDER GRAHAM BELL

THE Bell telephone is used in every part of the United States. It is named for its inventor, Alexander Graham Bell. Every famous man who has given something new to the world owes much to the work and discoveries of other people. Perhaps it is for lack of time and money to complete their inventions that the names of these other people are never known. But credit is usually awarded to the man who gives to the world the finished product ready for use.

It happened that the day that Bell filed his claim to the telephone at the Patent Office that Elisha Gray filed a similar claim. This was February 14, 1876. But it was later proved beyond doubt that Bell deserved the honor of first discovering the secret of the telephone.

Bell was an elocutionist. His first interest was in the study of the human voice rather than electricity. Both his father and his grandfather had made a study of the human speech. They taught the deaf, corrected stammering, and invented what they called "visible speech" for the use of people who spoke a foreign tongue. So Bell knew much of the laws of speech and how waves of sound from the human voice are carried through the air.

Bell was born in Scotland and educated in England. He began to teach elocution at sixteen. It was then he first met some noted men who were working on the musical telegraph and trying to send sounds over wire by using electromagnets.

American Telephone & Telegraph Co.

ALEXANDER GRAHAM BELL

Because of ill health, Bell came with his parents to Canada shortly after this. From there he went to Boston to teach deaf-mutes. He was engaged to give

private lessons to the son of a wealthy man and went to live in his home in Salem, Massachusetts. In the cellar of this home he had a workshop, and here he experimented with sending sounds by means of tuning forks and electric batteries. Bell worked at this for three years or more. He was trying to invent an instrument that would do more than the telegraph. He wanted something that would convey all the sounds of the human voice.

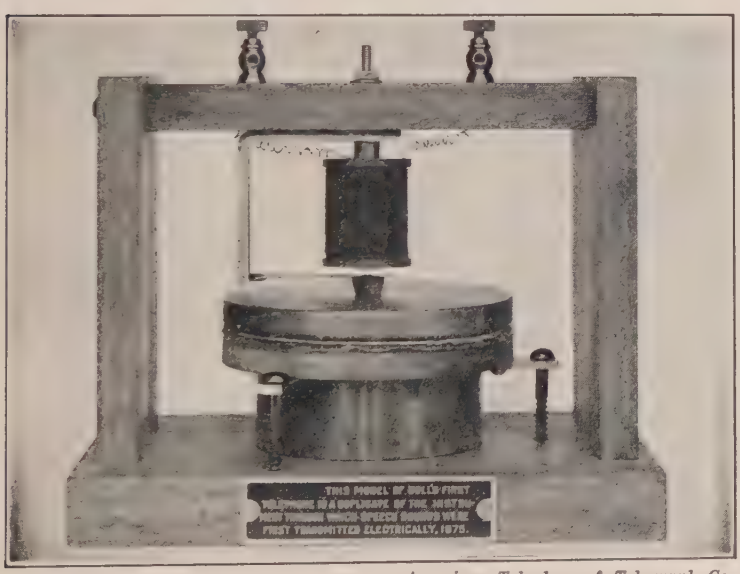
By working with his deaf pupils Bell had learned much about the sounds that affect the delicate eardrum. He constructed two iron discs similar to those of the eardrum and connected them with an electrified wire. The disc at one end sent these vibrations through the wire to the other disc which gave back the vibrations in the form of sounds. These he used successfully in conveying sound for a short distance. Bell was now about twenty-eight years old. When on a trip to Washington he saw Joseph Henry, who knew a great deal about electricity. Henry listened to Bell's plan with great interest and told him he had an idea with great possibilities.

"I don't know enough about electricity," said Bell.

"You can learn," replied Henry. "You have the idea for a great invention."

How often a few encouraging words have helped the downhearted inventor to struggle on to success! Bell went back to Boston and rented a room and studied electricity day and night. His assistant was a faithful friend, named Thomas Watson, who helped him make the vibrating discs.

One day in 1875 when the two men were working together, Bell was in the workshop bending over the end of the wire and Watson was in the room adjoining. Suddenly Bell caught a sound from the disc in his room. He called to Watson to repeat the sound



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ALEXANDER GRAHAM BELL'S FIRST TELEPHONE

he had made at his end of the line. Again Bell heard the sound carried to his disc by the wire. He had proved at last that a sound could be carried over a wire and reproduced at the other end.

It was a long time, however, before words could be heard over the wire. The receiving instruments only gave out loud noises. But Bell kept at work; for he

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BROADWAY AND JOHN STREET IN 1890

knew that the different sounds of the human voice were only differences in vibration and if the wire would carry one sound, it would another.

American Telephone & Telegraph Co.

BROADWAY AND JOHN STREET IN 1916

On March 10, 1876, the new instrument talked. Bell had sent Watson to the basement to one end of the wire. Soon Watson heard Bell say clearly, "Watson, come here; I want you."

Watson ran up three flights of stairs crying: "I can hear you! I can hear the words!"

Thus Bell's knowledge of the human voice had aided him in the discovery of the telephone. The other men who were trying to solve the problem all worked from the electricity end, and failed to reproduce the differences in tones which make speech.

Now came the time that all inventors reach when they have succeeded in producing the thing they have worked for. How could Bell bring his invention to the attention of the public? One of his students was a Miss Hubbell who was also interested in teaching deaf-mutes. Bell and Miss Hubbell were soon to be married, and her father took an interest in Bell's invention. His influence placed Bell's telephone on exhibit at the Centennial Exposition at Philadelphia. Bell thought he could not afford to go to the Exposition, but the last minute as he was seeing Miss Hubbell and her father off, she persuaded him to accompany them.

When the judges reached the booth which contained the telephone, they were tired and hungry. They were inclined to pass it by with a joke; but at that moment the Emperor of Brazil who had visited Bell's deaf school in Boston came walking by. He greeted the inventor, and said he would like to listen at the telephone. The emperor put the receiver to his ear while Bell's helper spoke from the other end.

"It talks!" exclaimed the emperor. He was greatly amazed and delighted. With him was Joseph Henry, who had encouraged Bell at Washington, and Lord

Kelvin, the first engineer of the Atlantic cable. Lord Kelvin declared the telephone to be the most wonderful thing he had seen in America.

Because of the attention from these noted men, the telephone became the most interesting exhibit at the

American Telephone & Telegraph Co.

SWITCHBOARDS

Centennial. But though it satisfied the scientists, business men could see little promise in it. They said it was only a plaything that could not be made of practical service.

Bell had no money to push his interests and knew little of business methods. But he began to advertise through the newspapers and went from city to city lecturing about his invention.

In May, 1877, a man leased two telephones. In August of that year, there were more than seven hundred instruments in use, and a company was formed to push the Bell telephone. They offered their patents to the Western Union Telegraph Company for one hundred thousand dollars, but the president laughed and said, "We have no use for your toy."

About this time Edison had invented a new transmitter that greatly improved the instrument. The Western Union Telegraph Company got possession of this, and then tried to prove that Gray was the rightful first inventor of the telephone, so they would not have to pay for Bell's patent rights.

For a year a fierce legal battle was waged between the Bell Telephone Company and the Western Union. In the end the Western Union was forced to grant Bell the rights of the invention. They compromised by selling the Edison patent of the transmitter to the Bell Telephone Company, and agreed to keep out of the telephone business.

In 1881, the Bell Telephone Company was reorganized with a capital of six million dollars. There are more messages sent now in a day by telephone than by both telegraph and letter.

The telephone is so common that we seldom ask how it works, but perhaps you do not know. When you speak into the transmitter, you send the vibrations of your voice against a small disc of sheet iron. This disc trembles just as the vibrations of your voice vary. The disc can convey as many different vibrations as there are sounds. A piece of copper wire

connected with an electric battery stretches from the disc against which you have spoken to another disc at the other end of the line. The vibration of your disc sends an electric thrill along the wire and reproduces it on the disc at the other end. The receiving disc reproduces the sound in the receiver.

Now we know that these sound waves can be sent and received by the wireless telephone without having copper wire reach all the way between. But fifty years ago the marvelous new discovery of the telephone was one of the greatest helps to progress.

Questions and Problems

1 How came Bell to be interested in the telephone?
2 How did his early occupation aid him in working out the telephone?
3 When he found he needed to know something about electricity what did he do?
4 Who was Bell's helper?
5 Tell about Bell's experience at Philadelphia.
6 Who tried to get the patent away from Bell? Result?
7 What would be some of the inconveniences of to-day if we did not have the telephone?
8 Describe if you can how the telephone works.

CHAPTER XXIII

THOMAS ALVA EDISON

THOMAS ALVA EDISON was born at the beginning of a new age. It was called the Age of Electricity. People were just beginning to discover the many uses of this great new power, and probably Mr. Edison has added more than any other man to the wonderful inventions of this age.

Mr. Edison was born in Milan, Ohio, in 1847. His father was in business, and his mother was the well-educated daughter of a minister. She had been a school-teacher, and took a deep interest in her son's early training.

Edison's great-grandfather lived to be one hundred and four years old, and his grandfather was one hundred and two when he died, so Edison inherited great physical strength and endurance.

However, he was rather delicate of body but a lad with a very large head. Edison says of himself that he was different from other children and was greatly misjudged. He asked questions till he disgusted all the older people. The worst of it was he did not believe what was told him and wanted to experiment for himself. The doctors feared his large head might indicate brain trouble, and the neighbors were sure he was not bright. One of his teachers declared he was addled. This made his mother so angry that she

undertook his education herself. Together they read many long volumes of history that were popular in that day. His father encouraged him by paying him a small sum for every good book he read. So, very early, Edison got the habit of good reading, careful study, and independent thinking.

As a small child he was always in trouble. Once he fell in the canal and came near drowning. At another time he nearly smothered when he fell into the grain in his father's grain elevator. The tip of one finger was cut off when he allowed another boy to cut a skate strap with an ax while he held it.

When he built a fire on a barn floor and burned up the barn, he was publicly whipped as an example to the other boys. His mother did not worry about him. She believed her son was destined to do something worth while in the world, and she let him get all the experience he could.

When they moved to Port Huron, Michigan, Alva wished to become a newsboy on a train between that city and Detroit. For the first time his mother objected. It took him a long time to convince her it was wise. But the lad was determined, and soon he was making the trip every day.

He had already become greatly interested in science; his mother's cellar was lined with bottles labeled "Poison," so no one would touch them. Afternoons between trains he read science in the Detroit library. He had a place in the baggage car where he printed a newspaper of his own. He collected all the information he could about electricity,

and was busy every minute until he got home at half past nine in the evening. Then he read till late, and his father had a hard time to make him go to bed. He and his friends built a telegraph line between their homes. It was not an easy matter to get insulators and instruments in that day. The line was made of stovepipe wire and old glass bottles; he tells us an old cow walked off with the wire, but in the meantime the boys learned a great deal.

Edison made from eight to ten dollars a day with his railroad paper route, and showed his business ability. Sometimes he had the news telegraphed ahead and put on the bulletin boards in the stations. Then there was a great demand for his papers when the train arrived.

One day while he was experimenting in the baggage car, he set fire to it. An angry conductor threw him off the train at the next station, and boxed him so hard on the ears that ever after his hearing was affected. This deafness, Edison has said, was really an advantage to him, for it was only in the outer ear. He was kept from hearing many things he did not care to be bothered with and could concentrate in his thinking. Edison heard very well with an instrument close to his ear and when he came in contact with an instrument which he could not hear, he invented a better one that he *could* hear.

Now that his paper business was gone, Edison worked on his telegraph. He became an expert telegrapher. He needed only a few hours out of the twenty-four for sleep, so he read a great deal, and the

knowledge he gained became useful when he was a telegrapher and had to fill in gaps in the news carried by imperfect instruments and wires.

Four years after the Civil War ended Edison was out of work. He went to New York. He was allowed to stay in the building of the Gold Exchange where the transactions of buying and selling were sent out to all the brokers in the city. He looked over the complicated instrument that sent out the message and studied it thoroughly. One day it came to a standstill. Three hundred boys, one from every broker's office in the city, came running to report that the wires were out of order. The man in charge was completely confused, but Edison guessed where the trouble was and fixed it. In two hours everything was working again. Edison was called to the office of the inventor of the machine, offered charge of the whole plant, and given three hundred dollars a month.

Edison was now twenty-two years old. He worked twenty hours a day at his new job, and made good. A few years later an invention of Edison's which improved the ticker was brought to the knowledge of the president of the company. Edison was asked how much he wanted for it. He had worked day and night on it, and wanted to ask five thousand dollars. He had about made up his mind to ask three thousand when he lost courage and said, instead, "I think I will let you name the price, General."

"How would forty thousand do?" asked the General.

Edison was handed a check for the amount. It was

the first check he ever received, and he staggered out of the office, stunned by his good fortune. He made this money last a good while to aid him in his experimenting.

Questions and Problems

1 Tell of Edison's youth.
2 He read much and he also experimented. Which do you think did him more good?
3 Tell how he used his head in carrying on his railroad paper route.
4 Do you think it was really good fortune when he was thrown out of his paper route?
5 When in any man's life may misfortune become good fortune?
6 Tell the story of Edison and the ticker.
7 Is it always safe to let the other fellow name the price of your work?

CHAPTER XXIV

EDISON'S INVENTIONS

WHEN Edison was a telegrapher he began his inventions. While in his office he took many messages from Congress. He worked out an apparatus that would count the votes of the Congressmen as fast as they registered them and would have saved a great deal of time. But when he offered it to the government, they informed him that the votes could not be counted that way.

"Then," says Edison, "I learned my first lesson. If you are going to invent, invent something that people want."

After the Civil War Edison found there was demand for a machine that would send secret messages over the wires. He went to work on the idea, and in time had a method by which he could send four messages over a wire at the same time. One day he tapped a private wire between New York and Philadelphia, and heard a message which he knew was supposed to be secret. A few weeks later when he was in New York, he went to the sender of this message and repeated it to him. The man was shocked and frightened. He allowed Edison to install the new apparatus for him, and paid him liberally.

Along with Edison's experiments with electricity

he studied chemistry. He worked while others slept. One day he got hold of a book by a scientist named Faraday. He started very early in the morning, and read steadily until breakfast time. Then he said to a friend, "I have so much to do and life is so short, I am going to hustle."

Edison became closely associated with a man who worked with Alexander Graham Bell, the inventor of the telephone, from whom he learned much. In 1877 he invented the talking machine, or phonograph. It grew out of his attempts to have his telegraph messages record themselves. Even the men in his shop laughed loud and long when Edison said he would make a machine that would reproduce the human voice. Edison practiced a long time with the discs that we use to-day, but finally succeeded with a cylinder which had tin foil wrapped around it.

In the same year he began experimenting with the electric light. Edison has invented many things, but it is generally agreed that his greatest contribution to the world is his incandescent light and the system he worked out for distributing electric light, heat, and power.

To-day we switch on the electric light with never a thought of the day when there was no such convenience, but it was only forty years ago that Edison was laughed at as a madman because he proposed to light houses with electricity.

Other experimenters had tried to make a single large lamp, but Edison set out to divide the electric light so it could be used in small units like gas.

Copper was used as a conductor, but the cost of copper was too great to be used in a system of lights such as Edison planned. He made numberless experiments with carbon, but the lights burned only a few minutes. It was in 1877 that he discovered if he used a piece of platinum wire in an all-glass globe completely sealed without air, and passed a current of electricity through it, the wire would give light without melting.

Having found the glass-globe idea with the air excluded, he carbonized a piece of sewing cotton and had it sealed into the glass globe with practically all the air forced out. When put on the electric light circuit, this lamp burned for forty hours. Edison and his fellow workers hardly ate or slept during this time, so great was their excitement and joy.

Then Edison began carbonizing everything in the form of a string he could lay his hands on—all kinds of thread, twine, lamp wick, paper, and cardboard. It is said he tested six thousand kinds of vegetable growth.

One day he picked up a palm-leaf fan and cut filaments from the binding on its edge. He carbonized these filaments. This bamboo proved the best conductor he had tried. He sent a man to Japan to get bamboo. A special kind was found that worked. He hired a Japanese farmer to raise quantities of it for him. Meantime he was seeking the world over for a better fiber. After he had spent a hundred thousand dollars hunting for a fiber, he succeeded in using a filament of a cellulose mixture made into the form

of a thread that answered his purpose and took the place of the bamboo at much less cost.

For three years he sold the incandescent lights for much less than it cost him to make them; but the fourth year he succeeded in reducing the cost, and the demand for them was so great that he made up what he had lost.

Edison's lamp was followed by his system of distributing electric light, heat, and power from a central station. He invented ways of supplying currents for separate buildings and meters for measuring the electricity used. He designed new dynamos and methods of preventing fires from switches and fixtures. He first demonstrated electric lighting in a house into which he moved and wired according to his ideas. Here he had thousands of visitors.

But Edison was always so full of new ideas that he had no time to worry over failures and hardly had time to rejoice over his successes. Once in a while, he says, he stopped long enough to figure out a way to pay his debts.

He saw the need of a storage battery for electricity. The only type known was one made with lead plates and sulphuric acid. He completed ten thousand experiments before he got a start. He tried all kinds of metals, and finally secured a reaction between nickel and iron.

Then with chemists and engineers he settled down to ceaseless work. Night and day they kept at it. At midnight a lunch was sent in, and they took a little

rest. Along toward morning Edison would curl up on a table or a desk with two books for a pillow and get a few hours of sleep. One of his friends said he "never seemed so happy as when he ran against a snag."

He had to build his own plants and train his own chemists. He tried more than fifty thousand experiments and worked for several years before his storage battery was complete and ready for sale. The use for which he intended it was the transportation of freight and passengers by motor car and street car.

Edison perfected a system of train telegraphy between stations and moving trains which was the beginning of wireless. During these years, he became interested in moving pictures. Photographs were then taken with plates. He had to invent a sensitive surface of such form and weight that the pictures could be taken very rapidly, one after the other. While he was experimenting with a cylinder, the Eastman Company developed the kodak with the film.

When they had improved the film, Edison adopted it and began to work on a camera where a long roll of film could pass steadily behind a lens, while at every inch the shutter would open and close. This was repeated sometimes forty times a second on a thousand feet of film. In four years Edison had made the first motion-picture camera.

Edison rested from his electrical experiments and worked many years to make Portland Cement, and made the model of a poured cement house which could

be built very cheaply for people of very small means.

During the World War, Edison devoted his time to war needs. He planned and built nine chemical and two benzol plants. Many products that the United States got from abroad were then cut off. Edison set to work to produce them. Carbolic acid was needed by the government for explosives. By working gangs of men in eight-hour shifts twenty-four hours a day, in eighteen days Edison had built a plant and was turning out carbolic acid. The demand was so great that he constructed a second plant, and was soon turning out six tons a day. This was only one of many needed chemicals which he produced for the government and for manufacturers.

When it was certain that our country would be drawn into the war, Edison agreed to give his full time to the government free of charge. For two years he devoted his time to war interests, chiefly the submarine. He invented an apparatus by which torpedoes could be heard three thousand yards away. Then he began to work upon a plan for the quick changing of a ship's course. Many other projects were suggested to him, and he worked tirelessly until the armistice was signed. Then he went back to his own interests, and we cannot tell how much more he may have to offer the world.

Questions and Problems

1 What lesson did Edison learn when Congress turned down his vote-counting machine?
2 Of what significance was it that Edison worked while others slept?
3 Tell about the phonograph and describe if you can something about it.
4 Tell of Edison's struggle to invent a satisfactory electric light bulb.
5 What can you say about the motion-picture camera?
6 What was Edison doing during the World War?
7 Read a life of Edison from the library and name his inventions.

CHAPTER XXV

MARCONI AND THE WIRELESS

GUGLIELMO MARCONI was born of English parents in Bologna, Italy, in 1874. He was hardly more than a youth out of college when he became famous. While he was still in his twenties, he became the inventor of the first successful wireless telegraph.

From Marconi's childhood he had been devoted to the study of science. When he was only twenty-one, he had invented a wireless transmitting apparatus. Other great men had worked on the problem of the sending of messages without wires. Edison had sent messages to moving trains. Morse had telegraphed under a river without wires. In 1854, Lindsay sent a message through water two miles without the use of wires. But it was left to Marconi to complete the solution of sending and receiving wireless messages in a practical manner, and it was he who caught the first sound to come by wireless across the sea.

First he telegraphed a distance of two hundred and fifty yards across the Thames in England. In 1896, he sent a message across the English channel to France, which was thirty-two miles. And in 1901, he covered more than three thousand miles and received a message in St. John's, Newfoundland, sent from the coast of England.

—*Kadel & Herbert*

GUGLIELMO MARCONI

Marconi lived in a different world than that of the early inventors. To-day the world is waiting to welcome new inventions with open minds, but news travels so fast, that if a man is to safeguard his secrets until they are protected by patents, he must work very quietly.

One day in the year 1901, Marconi sat in a little room in St. John's with a telephone receiver at his ear. He had quietly made all his arrangements in England to have a signal sent to him from the coast of England at certain hours each day. At these hours he was going to try to catch the signal. No one was in the room but Marconi and his assistant, Kemp. On the table before him was his instrument; a wire led from this apparatus to a very large kite that was flying in a wind about four hundred feet above the housetop. Kemp and Marconi tried several times before they could safely send up their kite. One kite and a balloon had been carried out to sea. But now this one flew bravely aloft holding the end of the wire.

Suddenly Marconi handed the receiver to his assistant. "See if you can hear anything, Kemp," he said quietly.

The other man seized the receiver and listened. Almost at once he joyfully replied that he could hear very distinctly three little clicks, which were the three dots representing the letter *S* of the Morse code. This was the signal that Marconi had arranged to have sent from England. Over and over again the signal was repeated until there was no doubt of the success of the experiment.

When Marconi left Newfoundland, he was besieged with letters and telegrams with invitations to lecture and write articles for the press. Congratulations came to him from all over the globe. When the train stopped at stations a crowd gathered to see the inventor, so fast did the good news travel. In a few days the newspapers had spread the news everywhere. Such men as Edison believed it at once, and

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Ship Used by Marconi in Experimental Work

it was only a short time until the wireless telegraph was in actual operation.

A year later Marconi had regular communication between Nova Scotia and England, and in 1903 Roosevelt sent the first official message to King Edward of England. One of the first messages about Marconi's success went to his parents. To be sure the Cable Company ordered Marconi out of their territory, and

people doubted whether wireless messages could be controlled, but in a few years the wireless message was a common thing. Out of it has grown the radiophone with which thousands of homes are now equipped.

Let us see if we can understand how a wireless message is sent. When the telephone was first discovered, many people believed that there was a hole through the wire through which the sound was sent. In time they understood that the wire simply carried electrical vibrations started by the voice from one point to another. Then it was found that certain vibrations can travel on through space without wires, and Marconi and others proved we could receive these messages if we knew how to intercept them.

Everywhere about us on the earth's surface and off to the most distant planet is a sea of ether, as scientists call it. We are not as conscious of ether as we are of the air, because none of our senses are affected by it. It is a mysterious something which we cannot hear, see, nor smell. But the energy of the sun's rays passing through the ether creates certain waves that scientists have learned to detect.

Hertz, a German scientist, discovered that a spark of electricity caused these waves in the ether to radiate in circles like the circles made by an object striking the surface of a body of water. Some of these rapid wave motions in the ether make light, others not so rapid make heat, still others electricity. If the ether vibrates 435 trillions of waves a second, we see the color red. We see violet if it vibrates 735

trillions per second. When it vibrates about 230 million times to the second, we get the Hertzian waves in the ether which Marconi used in his wireless.

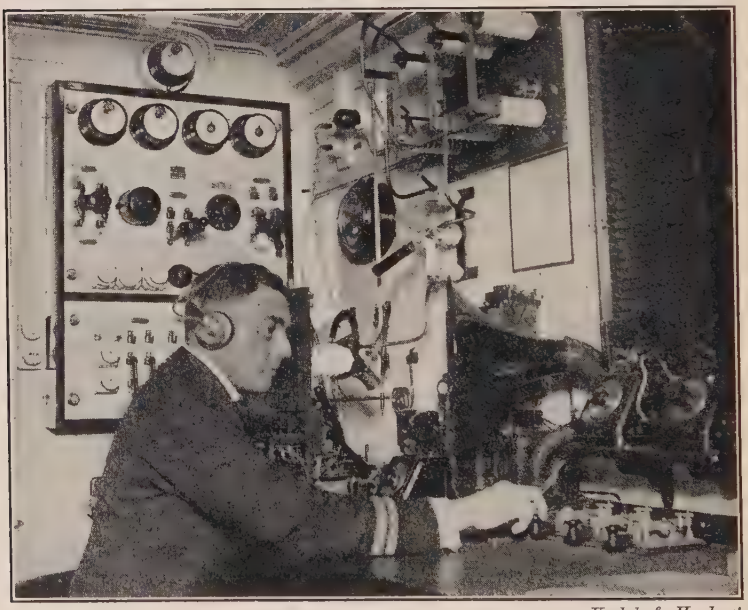
Ether must not be confused with air. If the air vibrates, our ears get sound. Sound waves sent through the air are much slower than ether waves. The lightning we see in a storm is in the ether, and the thunder is the sound that is brought through the air. Light waves in the ether always reach us first.

Marconi at his home in Italy began with tin boxes set up on poles in the ground. He generated a current with an electric battery and radiated it from a wire suspended from a tall pole. He turned on and shut off the electric current with an instrument like the key of the telegraph, and spelled the letters of the Morse alphabet.

It was easy to make a transmitter and to start the wave messages into the ether, but it was another thing to receive them. The most important instrument in wireless is the coherer. It was discovered by an Italian, but Marconi improved it. It is a little tube of glass about the size of a pencil and about half as long. The ends are filled with silver, with a narrow space in the middle in which is powdered nickel and silver. These substances form a good conductor of electrical waves when they cohere.

The ether waves come from the wireless transmitter which may be thousands of miles away and are received by the suspended wire and changed into electrical waves, but they cannot operate a telegraph instrument. They can draw the little particles of

silver or nickel in the coherer together so there will be a connection. These particles cohere and make a path for the electrical waves which operate the Morse instrument. Then a little instrument strikes the coherer and shakes up the particles until a new wave comes.



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THE RADIO ROOM OF A MODERN OCEAN LINER

When Marconi's first success was announced, every one asked how messages sent broadcast through the air could be kept secret. Marconi answered this by his tuner.

These Hertzian waves, like the waves of light,

travel very rapidly. They can circle the earth about eight times in a second. Wireless signals are these wave motions disturbing the ether. These ether waves are received by the coherer only when the instrument that sends them is tuned in with the instrument that receives them. The receiving station must intercept the waves and transform them into electrical vibrations that correspond with those sent out by the sending station.

This was the greatest thing that Marconi contributed to the invention. He invented the device that would send out certain wave lengths, and he constructed a receiver to respond to waves of the same length. When the two instruments were accurately tuned in, one could receive the message sent by the other.

Now, instead of Marconi's kite which flew high in the air, we have tall, wireless stations which support a wire or a set of wires called *antennæ*. On ships these antennæ are fastened to the masts. A wireless operator wishing to send a message to another station listens in by connecting his receiving apparatus to his antenna and the ground, and puts his telephone receiver to his ear. Then he adjusts his receiving circuits for a certain number of wave lengths, which tunes in with the station where he wants to talk. He sends out his letters that stand for the station he wants. When he receives a return signal, he knows that his message will be received. Messages that are broadcasted may be picked up by any instrument properly tuned to receive them.

The world welcomed the wireless, and the World War put it at once into service. Now we have speedy knowledge of ships that are in distress. When a vessel leaves port, it remains in constant communication with the shore and with other ships along its course. Steamship companies were the first to be interested in Marconi's invention. Submarines and airplanes were in communication with headquarters by radio during the World War.

The use of wireless telegraphy grew by leaps and bounds, but now it is in danger of being superseded by the radio telephone.

Questions and Problems

1 Who invented the wireless?
2 Describe the sending of the first wireless message across the Atlantic.
3 What is the ether? How widely does it extend?
4 Is air the same as the ether?
5 Do our ears catch waves of air or of ether that causes us to hear?
6 What different effects are made by waves in the ether?
7 Perhaps you can get some radio expert to explain wireless and the vacuum tube.
8 What are Hertzian waves?
9 Tell about the use of wireless in the World War.

CHAPTER XXVI

THE RADIO-TELEPHONE

THE Bell telephone brought neighbors very close together. It enabled merchants of a city to transact business without waiting for mail or messenger. The telephone was a wonderful help in hastening all transactions between people who did not live too far apart.

Then came the day when men wished to talk between cities. But the voice lost its power when it had traveled a hundred miles or so and some way had to be found to magnify the sounds either when they started over the wire or when they were received. For this purpose the audion or vacuum tube was invented by De Forest in 1906. It is an improvement over the coherer. The audion was first used in the radio-telegraph, but was later taken over by the Bell Telephone Company. The audion makes it possible for every home to have a radio-telephone.

The audion or vacuum tube is a small glass bulb like an electric light bulb. The air is exhausted to a high degree of vacuum. Within is a tiny filament at one side of the bulb and a metal plate at the other. The filament is lighted by a battery and there is a flow of current from the filament to the plate. The filament sends out only negative electrons so the current flows always from the filament to the plate.

A one-way flow of electrons reduces the vibrations so a telephone receiver can take them.

A flat coil of platinum wire is placed between the plate and the filament, called a grid. A very slight change in the electric power in the grid makes great changes in the power of the current that flows through the audion. Thus a very slight electric wave can be greatly amplified and by using several audions it can be made powerful enough to reach long distances. Very feeble waves from a long distance can also be amplified or made stronger so that the far-off voice can be heard.

It was the audion that made it possible to telephone with satisfaction from the Atlantic to the Pacific coast. The audion was used at the sending stations to amplify the messages and send them out with greater power, and again it was used at the receiving stations to amplify the sounds as they were received.

The Bell Telephone Company wanted to use the wireless telephone to reach places where wires could not be laid. The cable was too expensive. They wanted to talk across the Atlantic instead of using the signals of the Morse code. So they lent all possible aid.

In 1915 successful attempts at radio-telephoning were made between points on the Atlantic coast. Then they talked from Washington, D.C., to Panama. A little later a successful message was sent to the Pacific coast, more than twenty-five hundred miles distant.

While the World War was in progress in October,

1915, the first radio-telephone message reached Paris, France, from the United States. Conversation was actually carried on between our country and the Eiffel Tower in Paris, thirty-six hundred miles away. This message was also heard in Honolulu, forty-five hundred miles in the other direction. The man who spoke

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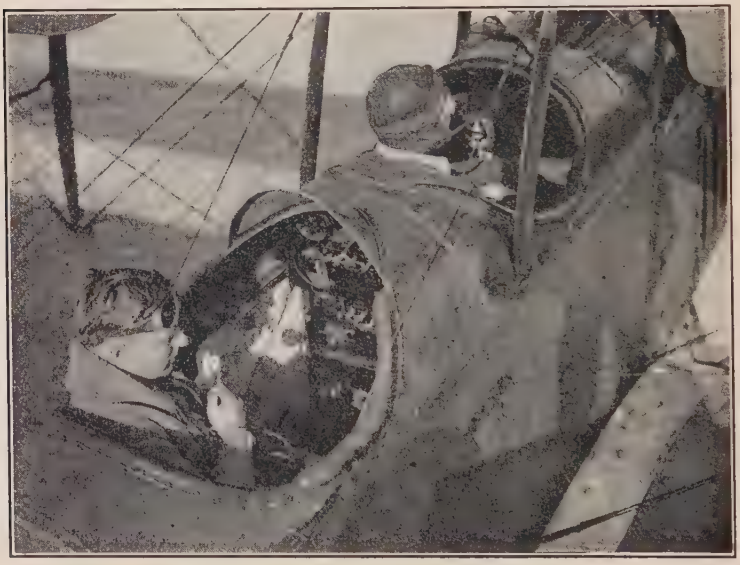
S.S. *Leviathan* Radio Room

was afterward heard to declare that his voice reached a third of the way around the earth.

As soon as the United States entered the war our government asked the inventors for an instrument that would enable ships to talk to one another and with the shore. Wireless telephones were needed for

submarine chasers and a small apparatus was worked out for them.

Then the inventors were asked to make a telephone for airplanes by which one could hear above the noise and jar of the plane. The inventors worked in a



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AEROPLANE EQUIPPED WITH RADIO TRANSMITTING OUTFIT

sound-proof room with a noise like the exhaust of an airplane engine to overcome. They succeeded at last in making an apparatus that was not affected by the jar and noise.

They next experimented with helmets for the aviator until they found one that was proof against noise. In this they fitted a telephone transmitter and re-

ceiver so when the aviator had it on his head the noise of his engine was shut out and he could clearly hear the messages. The antennæ of the airplane was a wire weighted to hang down from the machine. First they trailed it from the tail of the machine and later from the wings.

The next problem was how to supply the electric current. The generator which they first used was hindered by the different speeds of the airplane engine. This difficulty was also overcome. The apparatus used during the war weighed fifty-eight pounds and was supposed to make it possible to talk between airplanes three miles apart.

The instrument made for the submarine chasers was standardized at five miles. Wonderful improvements were rapidly made until the pocket sets were perfected to receive wireless messages.

When Amundsen, the explorer from Norway, set out in an Italian airship, the *Norge*, in May, 1926, on that dangerous flight over the North Pole, he carried a powerful Marconi transmitting set. The world listened in. The *Norge* kept sending such messages as these:

"We have sighted seals on the ice. Weather clear. We are not freezing. All well." "We have now lost sight of land. Only ice to be seen and several great polar bears. The whole view of this desert of ice is beautiful."

At last came this message: "We have reached the pole and have dropped the flags of Norway, United States, and Italy on the top of the world. The *Norge* has circled several times around the spot and now is headed on south toward Nome, Alaska."

Radio broadcasting has already overcome time and space. All nations are neighbors. The Eskimo, the Chinese, and the Mexican can tune in and get the world news. "Somehow the world, for all its diameter of eight thousand miles, seems to shrivel into a little ball which can be held in the hand," now that we have the radio-telephone.

Questions and Problems

1 What made the long distance telephone possible?
2 Describe the audion or vacuum tube.
3 What is the grid?
4 Why was 1915 a great year in the matter of communication?
5 How was the radio-telephone used on airplanes in the war?
6 How does the radio-telephone seem to change the size of the earth?
7 Show what a blessing it is to all mankind.
8 Do you think it will tend to make fewer languages used in the world?
9 How may the radio-telephone help to do away with war?

INDEX

Airplane, 106-115
Airship, 116-128
Audion, 201-202
Automobile, 91-96
Barber, John, 86
Battery, 42, 93, 94
Bell, Alexander Graham, 170-179
Bell reaper, 74
Bessemer, Henry, 17-25
Bible, the, 5
Blast furnace, 15, 16
Bomb, depth, 145, 146
Broadcasting, 202-206
Bronze, 10, 12, 18, 19
Bushnell, David, 129-131
Camouflage, 143, 144
Caxton, 9
Clermont, the, 61-64
Converter, steel, 21
Cotton gin, 50-56
Densmore, James, 154-159
Diesel engine, 87, 135
Dirigible, 117
Edison, Thomas A., 180-190
Electricity, 31, 41-49, 93, 94
Electric light, 186-188
Engine, 26-31, 85-90, 92
Ericsson, John, 65-73
Faust, 6-9
Fitch, John, 60
Franklin, Benjamin, 42-49
Fulton, Robert, 57-64, 131
Furnace, 13-16
Gas engine, 85-90
Gasoline, 92, 93
Glider plane, 108
Goodyear, Charles, 97-105
Greene, Mrs. Nathanael, 51, 52
Gutenberg, Anna, 1-6
Gutenberg, John, 1-9, 147
Harvester, 74-80
Helium, 123, 124
Henry, William, 60
Herz, 196, 198, 199
Holland, John P., 133-134
Housatonic, the, 131
Howe, Elias, 81-84
Hundley, the, 131
Hydrogen gas, 117, 119, 123-127
Hydrophone, 146
Iron, 10-16
Jackson, Dr., 160, 161
Kelley, 113
Kelvin, Lord, 176, 177
Lake Semon, 132
Langen, 87
Langley, 107
Lenoir, 86
Leyden jar, 41, 42
Liberty motor, 89, 90
Light, 196, 197
Lightning, 43-47
Linotype, 147-150
Livingston, Robert, 61-64
Locomotive, 33-40, 68
Los Angeles (airship), 123
Lowe, Thaddeus, 116
Mackintosh, 97
MacReady, 113
Mainz, 9
Manila twine, 79, 80
Marconi, Guglielmo, 192-200
McCormick, Cyrus, 74-80
Mergenthaler, Ottmar, 147-150
Merrimac, the, 70-73
Miller, Phineas, 53-55
Monitor, the, 70-73
Morse code, 168
Morse, Samuel, 160–169
Mother ship, 137
Motion picture camera, 189
Motor trucks, 94-96
Nautilus, the, 58
Novelty, the, 68
Otto, 87, 92
Oxygen, 141, 142
Periscope, 145
Phosphorus in steel, 23, 24
Pitt, William, 60
Princeton, 69, 70

Printing press, 1-9
"Puffing Billy" (locomotive), 38
Radio, 33-40, 198, 201-206
Railroad, 68
Reaper, 74-80
Remington and Sons, 156-158
Rocket, the, 37, 68
Rubber, 97-105
Rubber tires, 93
Rumsey, John, 60, 61
Schœffer, Peter, 4-8
Screw propeller, 68, 69
Sea gulls, 142, 143
Sewing machine, 81-84
Shenandoah (airship), 127
Sholes, Christopher, 152-159
Smoke screen, 143, 145
Steamboat, 57-64
Steam engine, 26-31
Steel, 10-16
Stephenson, George, 33-40
Stockton, S.S., 69
Submarine, 129-146
Telegraph, 160-169
Tin, 11, 12
TNT, 139, 141, 145, 146
Trevethick, Richard, 33, 34
Twentieth-century locomotive, 39
Typewriter, 152-159
U-boats, 136-146
Vacuum tube, 201-202
Vail, Alfred, 164-168
Watson, Thomas, 172
Watt, James, 26-32
Western Union, 178
Whitney, Eli, 50-56
Wireless, 192-196
World War, 112, 190
Wright, Orville, 106-113
Wright, Wilbur, 106-112
Zeppelin airship, 119-125
Zeppelin, Count, 116, 117, 119

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